SEX DIFFERENCES RELATED TO ACHIEVEMENT IN MATHEMATICS

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by SUSAN J. CAVENDISH

ABSTRACT

The study investigated biological, cognitive, and social factors relating to the under-achievement of girls compared to boys in mathematics. The phenomenon was investigated of girls being superior to boys in mathematics tests at the primary age but boys being superior to girls from adolescence.

Historical considerations appear to have contributed to the delayed provision of mathematics education for girls. Gender differences in tests were found in a few specific classes only and were not the general case. The analysis of errors found that language determines the level of success in mathematics during the early years. Other social factors such as parent attitudes and teacher confidence build up during the primary years to manifest from about the age of eleven and work to the detriment of girls. Secondary age boys demonstrated more positive attitudes than girls, but girls did not demonstrate negative attitudes.

The period between the second and fourth year juniors proved to be of significant importance in the development of mathematical achievement. During this period a change occurred in the types of test errors and omissions, the level of career aspirations, the number of male teachers experienced, the extent of whole class teaching, and pupil attitude scores. Teachers did not give more attention to boys compared to girls. A method of attitude assessment was trialled. Results suggested that most pupils viewed the teacher as a disciplinarian even though few discipline related interactions were observed in the classroom study. Male teachers appeared confident in mathematics, whereas females had less positive attitudes. Study of the classroom suggested that the curriculum area being taught influenced the teaching style employed which in turn influenced pupil behaviour. Differences within each curriculum area would allow for classroom factors to have a differential effect on girls and boys in mathematics and not other curriculum areas.

CONTENTS.

CHAPTER 1

STATEMENT OF THE PROBLEM AND SIGNIFICANCE OF THE STUDY.

1.1 Current Problems.

Mathematics, ever since it became part of the school curriculum, has always been viewed as a problem area for education. This despite the fact that the mathematics curriculum has been the subject of numerous reviews. The latest of these reviews, that of the Cockcroft Committee, illustrates this phenomenon, reporting that *' Mathematics is a difficult subject both to teach and to learn '* (Cockcroft,1982, para 228). Importance attached to this subject in these modern times is demonstrated by the fact that it is compulsory for all pupils to study mathematics every school year until they are 16 years of age. The Cockcroft Committee not only reaffirmed this importance but also went further by arguing that there were two uses of mathematics which couldn't be fulfilled by any other subject. Mathematics was important, (1) for its usefulness as a means of communication, such as in timetables and graphs, and (2) for its usefulness in other fields, particularly the sciences such as medicine and engineering (para 5). The committee accepted that there were other uses too, such as in developing logical thought and providing puzzles for enjoyment, but these could be catered for in ways other than through mathematics.

Mathematics, therefore, has been and is still considered essential, yet difficult to teach and to learn, and this has led to the inevitable expressions of dissatisfaction with the mathematical understanding of the young. Indeed, it was complaints from industrial representatives about the mathematical standards of school leavers which instigated the investigation into mathematics education by the Cockcroft Committee - an investigation of all aspects of mathematical attainment of children, of the teaching of mathematics, and of industry's needs. For example in 1973 and 1974 a number of articles appeared in a newsheet called 'Skill', published by the Engineering Industry Training Board, stating that the level of numeracy attained by most school leavers was inadequate for the needs of industrial training. Clearly then, the shortage of young people who are competent in mathematics appears to have been and still is a cause for concern.

Added to the difficulties of ensuring that all pupils gain a minimum standard of mathematical competence, there is a growing demand for pupils to be educated as mathematics specialists. The Cockcroft Committee, for example, saw ' *no likelihood that the demand for mathematics graduates will decrease - indeed, we believe that the demand will continue to grow....* ' (para 181).

Statistics of 1979 illustrate clearly the shortage problem - of 100% school leavers, 68% obtained CSE or 'O' level mathematics of any grade, 26% a good 'O' level (grades A,B or C) or CSE grade 1, 5.6% 'A' level (of any grade), but only ½% began a degree course in mathematical studies (Source: DES 10% Leavers' Survey). Although there has been some improvement in these figures over recent years, they have drastically failed to keep up with the demand of the new technological era of the computer or the demand for good teachers of mathematics and again, according to the Cockcroft Committee ' *the shortage of good teachers of mathematics has been a matter of concern for many years* ' (para 619).

There is, therefore, a need for good teachers to supply good teachers of the future, and without this the supply of mathematicians can never keep up with demand. At the same time, the shortage of good mathematicians means that schools have to compete with industry, a problem recognised by the Cockcroft Committee in that ' *mathematics graduates form a principal supply of mathematics teachers in secondary schools... the demand for mathematics graduates is increasing from many sections of Industry and Commerce and will probably increase further* ' (para 638). Thus there is a real need to increase the number of pupils studying mathematics to University level, and to increase the level of attainment of <u>all</u> children. This immediately poses the question of how this can be done. This study sets out to identify why many children fail to do well in mathematics and why many don't choose to follow mathematics to a higher level, at the same time as trying to identify why some children do succeed in mathematics and why some do aim for the highest levels of success.

As has been mentioned already, all pupils, both boys and girls, study mathematics up to the age of 16. Although girls at primary level show some superiority in mathematical achievement, a number of studies have reported a sudden change between 10 and 13 years of age when the levels of achievement have been found to be greater for the boys and to remain so thereafter (Maccoby and Jacklin,1974). In the 1979 'A' level mathematics exams only 26% of the entries were from girls, and this pattern must be reflected in the teaching careers of men and women. Clearly, then, two important points arise from these trends. Firstly, the shortage of mathematicians would be eased if girls could be encouraged to enter into higher mathematics, and secondly there is a need to encourage girls to become mathematics teachers. There is a need therefore to identify the factors which are causing girls to underachieve in mathematics. These factors may also have wider applications relating to the low achievement of slow learning pupils across the curriculum.

1.2 Research Issues.

Some local authorities, for example Essex, have been so concerned about the underachievement of girls in mathematics that they established committees to consider the problem and to make specific recommendations with regard to in-service training. The lack of research on the various aspects related to the underachievement of girls in mathematics, means that specific proposals for in-service are not based on empirical evidence but rather on conjecture. However, several explanations for the underachievement of girls in mathematics have been put forward. First there are explanations of a biological nature e.g. that hemispheric differences of the brain result in girls performing better in language skills, and boys in mathematical skills. Cognitive factors have often been cited as the reason for girls' underachievement in mathematics and science but the small differences which have been shown to exist suggests that such explanations are inconclusive (Maccoby and Jacklin,1974). Second it is argued that the boys' superiority in mathematics is due to the influence of visuo-spatial skills in which boys also have shown superior performance. The question of whether the superior performance by boys in these skills is the result of nature or of nurture is debateable, and so indeed is the question of whether such skills influence achievement in mathematics. It is argued, however, that girls' lack of opportunity to play with toys such as lego and building blocks are a contributory factor to the difficulties they experience in certain mathematical skills.

Third are explanations relating to pupil and teacher behaviour. It has been suggested that teachers pay more attention to boys and prefer teaching them (Schonborn,1975; Fennema,1979). Observation within the classroom should not only show if this bias of attention does occur but also determine whether the attention is teacher initiated or pupil initiated i.e. whether the teacher offers more attention or whether it is the boys who demand more and are more successful in achieving their demands. If it can be shown that boys do indeed get more attention it would then be possible to see if frequency with which the attention is received is correlated with levels of achievement.

The fourth kind of explanations concerns bias in texts. Books and tests may be devised in such a way that boys are favoured. Books may show boys as active and girls as passive when engaged in mathematical tasks and it is possible that these characteristics are displayed by pupils in the classroom and have an influencing effect on achievement.

Thus research on gender differences in mathematics has covered biological, cognitive and interactional areas. The latter can be divided into a wide number of approaches based upon the different hypotheses. The research has resulted in many explanations of sex differences in mathematical performance but few conclusions have been drawn. The explanations cited above may all be true but the full extent of their influence on mathematics achievement has not yet been determined. It is possible that there is an interaction of factors. If sex differences due to biological factors exist then the teacher, who cannot change biological factors, has to accommodate the sex differences. However, cognitive and interactional factors which are related to sex differences may be subject to influence from the teacher and the classroom situation and therefore this study concentrates on these areas which are pertinent to the class teacher. This study is different from previous published research in that it investigates all of the more important factors with the same sample of pupils rather than as other studies which have looked at one or two factors at a time (usually with different samples of pupils for each factor).

1.3 Previous Research: A Summary.

A comprehensive review of the published literature relating to sex differences in mathematics is provided in chapter 4. A summary is provided here in order that the relation between the present study and previous research may be clarified.

1.31 PUPIL ATTITUDE

The large proportion of published research studies on sex differences in mathematics has concerned the attitudes of parents, teachers and pupils, and the possible effect of these variables on the behaviour and achievement of the pupils. The Cockcroft Committee reported that ' *for the majority of schools, mathematics is a rather dull routine business both for teachers and children'* (para B18) and many studies have found that attitude to mathematics correlates with teachers' attitudes, parents' attitudes and also peer-groups' attitudes. Thus Bell et al (1983) saw that ' *it would seem important to look more closely at the nature of our classroom activities, trying to see them from the pupils' points of view, in order to understand their effect on the pupil's attitude '* (page 255). The present study attempts to do this.

It is generally felt that an attitude of liking for and interest in mathematics leads, perhaps through greater effort, to higher achievement and subsequently to a desire to follow a career involving mathematics. Little is known, however, as to when these attitudes are established. If the period during which such attitudes become fixed can be pinpointed, then programmes of intervention which take place before the critical age is reached may be effective in improving the proportion of pupils who retain positive attitudes to mathematics throughout their school careers.

According to Newbold (1977) the mathematical experience a child gets at primary school, whether good or bad, will affect the attitudes established in the child by the time he/she transfers to secondary school, and the Cockcroft Committee confirmed that ' *by the end of the primary years a child's attitude is often becoming fixed* ' (para 346). Thus investigation of attitude development in the primary years may be essential even when mathematics achievement of secondary pupils is under consideration.

1.32 INFLUENCE OF PARENTS

Newbold (1977) also suggested that ' *parents can exercise, even unknowingly, a considerable influence on their children's attitudes towards mathematics* ' (para 207). The impact of parents' views on their children may be related to their background and environment and the importance of social class must not be neglected in any study of a pupil's performance in mathematics, according to Mellin-Olsen (1976) in Norway who suggested that a child may have conflicting pressures from parents and from school. Relationships between a child and his/her parents did much to influence pupil's subject choice in school, and this could prevent girls from choosing mathematics at higher levels. Parental and pupil attitudes are investigated in the present study taking the above factors into consideration.

1.33 INFLUENCE OF TEACHERS

Parents are not the sole influence on pupils' attitudes. Teachers' attitudes towards mathematics are thought to interact with other teacher characteristics to affect the teaching and learning situation. Teachers have perceptions of children's ability which may or may not be accurate, and the ways in which he/she will group and teach the pupils will be influenced by these perceptions (Hargreaves,1967). If teachers perceive boys as superior in mathematics this may then have repercussions for the girls.

Another contributory factor may be the levels of expertise in mathematics which many teachers possess. Until recently, primary teachers have rarely had a degree qualification and, according to Ward (1979), may have felt insecure because of a limited knowledge of mathematics although the importance of possessing such a high level of knowledge has been questioned by Begle (1979). Ward also suggested that as most primary teachers are women who have themselves been alienated to mathematics they may lack the ability and confidence to be successful in teaching these skills to girls. The present study investigates teachers's attitudes to the teaching of mathematics as well as to mathematics per se, while also looking at teacher attitude to mathematics in relation to their qualifications and subject choice at training.

Fennema (1980) also stressed the important effect that teachers have on students' learning of mathematics and of their feelings towards mathematics itself. She admitted that parents have an impact too but believed that the most powerful influence is the teacher's daily interaction with the children, and Bell et al (1983) believed that *' The style and atmosphere of the activity in the mathematics classroom is a strong component of what is learned by the pupils '* (page 206).

Other researchers have seen pupils as the constraint on the teacher rather than vice versa. Each child has his/her own background experiences and learning capacity which affects the socialisation within the classroom, although whether the effects have the same impact at different school age levels is unclear. Nash (1973) has gone so far as to suggest that ' *all genetic and sociological factors are mediated and realised through the interaction between the teacher and the child in the classroom* ' (page 123), and on the subject of sex differences the Cockcroft Committee believed that ' *the question of classroom interaction and expectation is of considerable importance* ' (Cockcroft, 1982, para 212). The present study investigates such interaction and examines assertions that teachers praise boys more for work which includes high cognitive skills such as problem solving, while girls are praised for computational skills (Fennema, 1977). If such teacher characteristics which influence male and female achievement levels do exist and the teachers can be helped to recognise and identify these factors themselves, then they can attempt to modify their behaviour to eliminate such discrimination.

Roberts (1971) claims that very simple acts of teachers' behaviour may result in incredible changes in the pupils, but girls and the less able are thought to be more susceptible to this influence, particularly in secondary schools where individual pupil/teacher contact time is less than in primary schools. Providing teachers can identify anxiety or adverse attitudes in pupils, then again they can modify their teaching in ways which reduce these aspects of pupil personality. This study attempts to find new ways to assess a pupil's attitude including anxiety in mathematics, as there is no suitable method available for daily classroom use at present.

1.34 TEACHER STYLE

The amount and type of interaction with a pupil may be dependent on the way a teacher is working in the classroom i.e. her teacher style. American studies found that in 1976 to 1977, despite sponsored intervention programmes, teaching styles remained largely unaltered. In Britain the assumption, so far untested, is that with the emergence of new mathematics schemes and texts teaching styles have changed. This study includes an observational study of teaching and learning of mathematics within the classroom throughout one whole academic year, and compares it with data from the 'ORACLE' study on teaching styles and pupil types (Galton et al, 1980) to see what change if any have taken place in recent years. The study also uses the 'ORACLE' data to investigate teaching styles across different curriculum areas in the primary classroom, to see whether pupil and teacher styles in the classroom are dependent on the curriculum area being taught, or conversely whether the curriculum area influences teacher and pupil styles.

1.35 TESTING AND ERRORS

Mathematics is a very wide curriculum area and topics within it may vary from school to school. By utilising item analysis, performance on a test consisting of different mathematics topics can be investigated by comparing the success and error rate of each item with teacher style and pupil type which is determined from the observation study. According to the Cockcroft Committee ' *testing, whether written, oral or practical, should never be an end in itself but should be a means of providing information which can form the basis of future action* ' (Cockcroft, 1982, para 420). The present study attempts to develop a procedure for classifying errors made in test items which could provide valuable information about the pupil's understanding of important mathematical concepts. This should be of particular use to teachers.

It is also important to discover if certain teaching styles are more conducive to learning according to the area of mathematics being taught. Studies have shown girls to be inferior on certain mathematics tasks (APU,1978). It is therefore relevant to look for relationships between pupil gender and various mathematical topic differences with regard to teaching styles.

1.36 DEVELOPMENTAL STAGES

Because girls have been reported to be superior or equal to boys at primary level, it has often been assumed that the secondary schools are to blame for the subsequent underachievement of girls and research studies have, in the past, directed their attention to this secondary age. However, the foundations laid at an early age may lead to developmental causal factors of the 'change over' of superior achievement by boys and girls, and this possibility has hitherto been neglected. One interesting aspect of the present study is that it concentrates on the development of factors such as attitudes and behaviour in mathematics of 5 to 13 year olds covering the period during which girls are thought to do better than boys until the point in time when boys are thought to do better than girls. If developmental stages can be shown to occur it might be possible to find ways of intervening to enable pupils to gain these stages earlier particularly those that are conducive to higher attainment. This would obviously affect the ways in which teachers teach and also what teachers teach.

Within this observational study of teaching and learning in the classroom, throughout one whole academic year, an attempt is made to try to identify those aspects of teacher or pupil behaviour which affect the rate of achievement.

1.4 The Need for Research.

Research on the social context of mathematics education is extremely limited in quantity and according to Bishop & Nickson (1983) ' *Many of our conclusions are based upon surveys, analyses and extrapolations from results of research not carried out with specific reference to mathematics* ' (page 67). Bennett (1976) also expressed concern at the lack of research when he said that '...*in all arguments about teaching methods innovation is being urged without research* ' (page 9). Not only is there the need for more innovative research but also a need for replications of studies already carried out, because as Noel Entwistle (1981) pointed out ' *Given the weaknesses in social science data, and the problems in drawing inferences from them, it is important not to rely on the results of a single study or even a single research approach* ' (page 30).

The shortage of mathematicians is not confined to Britain. All countries that gave evidence to the Cockcroft Committee expressed a concern to improve the quality of mathematics education and the shortage of mathematics teachers is extreme in parts of the USA. A great deal of research has been done in other countries leaving Britain behind, yet the increase in performance of girls in mathematics could help to alleviate such a shortage of mathematics teachers.

The Cockcroft Committee recognised that of girls' comparative underachievement in mathematics ' *a good deal of research quoted... was undertaken in the USA and it is not clear how accurate is its application in the British education system....* ' (para B41). This study aims to contribute to this need.

CHAPTER 2

GENDER DIFFERENCES IN MATHEMATICS: AN HISTORICAL PERSPECTIVE.

2.1 Introduction to Historical Considerations.

Underachievement is a term often used in literature on research into mathematics education. This implies that the pupils are capable of attaining higher levels of performance than they have actually achieved. The term underachievement is however a problematic one, since it is difficult to demonstrate that a child is underachieving until s/he demonstrates that s/he can achieve more by actually doing so. Spokesmen from industry have complained that mathematical skills of the young are inadequate for the needs of industry but to accept this criticism is to leave unanswered the important issue of the cause of such inadequacy. Is it because the schools haven't provided effective teaching, or is it that the content of the mathematics curriculum is inadequate for industry's needs, or is it that children have reached their mathematical 'ceiling' beyond which it is impossible to go? If the cause of the inadequacy is the schools inefficiency or the inappropriateness of the curriculum then one would expect most children from the same school to be deficient in the same way but this is not generally the case. If the lack of mathematical skills in higher education is due to pupils inability to extend their competence beyond a fixed ceiling, then one would need to ask whether the majority of girls have a lower ceiling than boys, given their absence from these higher level mathematics courses. If this constitutes an explanation for the sex differences in mathematics attainment which have been reported then it is still necessary to discover why some girls, few though they may be, go on to University level to study mathematics, and why some boys fail to reach these higher levels. By themselves, therefore each of these explanations is unsatisfactory. An interaction of several factors thus seems most likely. If instead we assume that boys and girls have similar mathematical ceilings (if they exist at all), then we can say that by the time of higher education the majority of girls are underachieving and the causes of this underachievement is the main focus of the present study.

Although great importance is attached to mathematics in present times, anxieties and difficulties and feelings of dislike of the subject are widespread and according to the literature this is particularly so for girls. The aetiology of these anxieties may go back a long way into the past. Mathematics however is a relatively recent addition to the formal curriculum in schools and the school system has changed radically over the years. It is possible, therefore, that the development of the educational system may have contributed to the establishment of gender differences in mathematics. To understand how some of today's problems may have developed and why it is that more girls experience these problems than boys, it may be helpful to attempt an historical perspective of certain aspects related to mathematics achievement before concentrating on the situation as it is today.

2.2 Women and Mathematics in Ancient Times.

Although mathematics is a relatively recent addition to the school curriculum, evidence exists that people had some experience of it prior to 1650B.C. Around this date the Ahmes Papyrus described mathematical games used for family fun and this suggests that women as well as men were familiar with mathematics as it existed in this age and in this culture (Osen,1974). However, it is known that the early Egyptians did not allow women to learn to read and write and thus it is clear that women throughout the world received very different educational experiences from each other and sometimes from men. In fact it was not until the Hellenic age that evidence emerges of the existence of a few learned women. Men however had their struggles too since many were denied the opportunity to learn, such opportunities being limited to those leading a religious life.

The situation for women was even more difficult as attitudes against women learning mathematics were very strong. Around 539B.C. when Pythagoras, who was known as the "feminist philosopher", founded a school in Southern Italy for the Science of Mathematics, his associates opposed sharing this school with women. Pythagoras insisted that he wanted everyone to learn the joys of mathematics and his view prevailed against that of his associates. Women were admitted to the school, including his wife Theano and at least two of their daughters. As the Pythagorean Order believed that ' *all things are numbers* ' the school's curriculum included aesthetic areas such as music and dancing which, because of society's acceptance of women's participation in these aesthetic areas, ensured all women would share in the mathematical philosophy. This philosophy of mathematics across the curriculum rather than as a subject separate from other subjects, is still being advocated today, as mentioned by the Cockcroft Committee ' *the experiences of young children do not come in separate packages with 'subject labels'; as children explore the world around them, mathematical experiences present themselves along others'* (para 325).

Plato too was influenced by the Pythagorean school and appreciated the intelligence of women. He believed that education should be compulsory for all (Cornford,1953) and wrote ' *All the pursuits of men are the* *pursuits of women* ' (Jowett,1892). With the existence of such liberal attitudes so long ago it is difficult to understand why these attitudes are still lacking in many people today.

Aspasis was one of the Greek women associated with Plato and through her influence she convinced the ruler Pericles that women should be allowed the opportunity for intellectual development. Most women, however, were still only allowed to live in seclusion so that very few women became noted for their intellectual pursuits. A number of prominent women mathematicians were mentioned by Athenaeus A.D.200 (Osen,1974) but precise knowledge of their work is lacking because the work of all students of Pythagoras was attributed to the school rather than to individuals within the school. The first woman mathematician of whom we have detailed information is Hypatia A.D.370 (Hubbard,1908). She was famed for her mathematical .skills, and became a teacher of mathematics at the University of Alexandria. In Hypatia's time astrology and astronomy were considered one science with the principle aim of trying to foretell the future of souls. Mathematics was the bond between this science and religion. The link with religion meant that Hypatia was very powerful. A woman in a powerful situation was not easily tolerated by others with influence and ultimately this antagonism led to her death. Hypatia loved mathematics, perhaps because her father, a professor of mathematics, influenced her by rearing her in an atmosphere of learning, questioning and exploration. Without this parental influence it is doubtful whether Hypatia could have overcome the obstacles placed in the way of women holding important positions in the University, even if she had developed a love of mathematics through her own motivation. Parental encouragement may still be an important determinent of mathematics achievement of girls in the present as it was in Hypatia's time.

Following the death of Hypatia, there was a general decline in learning and civilisation and women were refused higher education, some being denied the right even to read and write as it was considered a source of sin and temptation. This was not true for men. The desire to spread Christianity resulted in the establishment by the church of boys schools in various parts of England e.g. Canterbury, Westminster and York. Priests needed to read the Bible and hence be literate. The curriculum was therefore based on the needs of the religious life. Arithmetic and astronomy were taught because of the need to calculate moveable feasts such as Easter, and also to enable basic accounts to be kept. Thus educational provision existed for a few boys only, but these few boys had a greater chance of experiencing mathematics than did any girl. The first institutions for the education of girls in Christian Europe, outside of the home environment, were probably the nunneries, with an emphasis on teaching the faith and good behaviour. With learning confined to monasteries and nunneries, the 'mysteries' of mathematics, when taught at all, were limited to those who shared the same religious faith.

Education became more generally available first to boys and the curriculum included basic arithmetic, whereas when it finally became available for girls there was very little provision for development of computational skills. At this point in time, however, the theory of mathematics hadn't developed very far so it would not be expected that anything more than arithmetic would be taught in any institution. The academic development of mathematics as a science had to wait until the thirteenth century which brought the arrival, to England, of Arabic ideas and notations (Howson,1982). This facilitated some development of mathematical thought but communication of ideas and theories between people was virtually impossible until the advent of printing in the 14th

Century. Until this time there was little opportunity for men, let alone for women to increase their mathematical skills.

2.3 Women and Mathematics in the Middle Ages to the 17th Century.

Most girls who were lucky enough to be in education were denied the opportunity to study even arithmetic. In the Middle Ages, day schools existed for a minority of girls but in these schools pupils were only taught simple elements such as the ABC and usually the girls then continued their education by training for domestic duties. Inhabitants of the aristocratic homes of the 14th Century were accustomed to a high standard of culture, and a knowledge of vernacular literature was seen to be of importance for women as well as for men. Thus the social class to which a girl belonged and the influence of the home background often determined the type of education which she would be likely to receive. Most children who were educated at all were educated either privately or at home but the Church remained dominant as an educating force and was responsible for the education of one woman who became famous during the Middle Ages for her mathematical skills, a nun of the 10th Century named Hroswitha. It is claimed that she wrote that the sun was the centre of the firmament and its gravitational pull ' *holds in place the stars around it, much as earth attracts the creatures which inhabit it* ' (Mozens, 1913). This statement was made centuries before Newton's time and illustrates the degree of mathematical skill that women might have developed given the opportunity.

As the need for education, especially for boys, slowly became accepted the demand for teachers outstripped supply. As a result of this increasing demand a teacher training college was established at Cambridge in 1437, and soon after others followed. But even though the importance of education was becoming widely acknowledged, mathematics education failed to receive similar recognition - Vives mentioned that mathematics was taught mainly because of its usefulness and only later was it valued for its contemplative aspect too (Cornford,1953). Thus the number of teachers with a wide knowledge of mathematics as opposed to arithmetic would have been severely limited leaving little opportunity for their pupils to develop mathematical skills. The problem still exists to this day.

However, after the fall of Constantine, Europe experienced an influx of scholars with knowledge of science and literature and this helped spark off the 'Renaissance'. But the status of women changed only very slowly and France and Germany saw a revival of the anti-feminist crusade. In England, Henry VIII destroyed the convent system leaving women without any systematic education and it was a long time before similar opportunities again became available. This period saw the development of private literary schools, although these existed only on a very modest scale until the 17th Century. Universities remained hostile towards mathematics and so few men could study the subject even though their elementary education was advancing faster than that of girls.

The curriculum offered to girls was very limited. In 1523, Vives gave great thought to the curriculum of girls and recommended subjects which were all linguistic (Watson,1912). It was many years later that the curriculum was extended by Mulcaster to include music, logic, philosophy, rhetoric and drawing, but there was still an absence of mathematics (Mulcaster,1887).

The Restoration hindered development of educational institutions thus leaving education in the hands of private day and boarding schools throughout the 17th Century, but there remained a strong division of opinion on the value of learning for women.

The Renaissance had its origin in Italy and here the situation for women was different. Women had become lecturers and professors and the advent of the Renaissance brought them back into an active role in the educational movement. Women became famous in all subjects, and one such person, Maria Agnesi, became famous for mathematics in the late 17th and early 18th Centuries although her progress was not totally free from obstacles. Maria was the daughter of a professor of mathematics; her education was carefully planned and she became a proficient mathematician causing a sensation in the academic world. But despite this world acclaim the French Academy would not admit Agnesi because its constitution barred females. Eventually she was admitted to the more liberal minded Bologna Academy of Sciences. She never married and after her father's death gave up her interest in mathematics to care for the poor and sick. The encouragement from her father might be said to have been the main reason for her mathematical enthusiasm.

2.4 Women and Mathematics in the 18th Century.

In France, women received similar treatment to those in England. During the reign of Louis IV the first French school for girls was founded to educate daughters of nobility but the sciences were considered to be outside the needs and capabilities of such women and so intellectual activity in these areas was done secretly. It was in this climate in 1936 that Emile de Breteiul, who loved mathematics, came to public prominence. She had an affair with Voltaire and it was only with his encouragement that Emile was able to engage in her mathematical interests and become famous for her work (Osen,1974). Emile's career demonstrates that even when society is an obstacle to learning, some women have managed to override the problems perhaps partly through self-motivation but almost surely through the support of family and friends.

The influence of the family is also demonstrated by a girl called Sophie Germain who was born in France in 1776 and became interested in the study of mathematics which, as we have seen, was considered unsuitable for girls at that time. Her parents were so against her studying mathematics that they took steps to prevent her by forbidding her to have heat or light in her bedroom - parental influence at the extreme. But her determination and her motivation never ceased, and when her parents slept she used candles and blankets to keep her warm while she studied her books.

A great social change in Britain took place during the period leading up to the French Revolution: a demand for universal elementary education and a demand for equal treatment of boys and girls went hand in hand. Previously, although a few children of the poor had attended simple schools for young children, there was no differentiation of the curriculum as was the case for the older children of the middle and upper classes. The curriculum gradually changed as the ideas of the French revolution began to influence educational thinking. The result was a somewhat crowded curriculum which included music, dancing, calligraphy, accountancy, housewifery, cookery, fancy crafts, needlework, diction and deportment. There was little mention of mathematics and the sciences. This kind of overcrowded curriculum developed during the 18th Century into the well-known 'regime of accomplishments' and the schools which were frequented by the girls of the upper classes became discredited. With so many subjects being taught none could be taught well. Meanwhile, charity schools with an industrial, and hence utilitarian emphasis, were developed for children of the poor, with an emphasis on arithmetic rather than mathematics.

Tuition in mathematics in England was scarce for boys as well as for girls. In 1737, to remedy the situation, Charles Hutton established a private school purely for mathematics. Grammar school boys often paid to attend this private school as mathematics was rarely part of their grammar school curriculum.

2.5 Women and Mathematics in the 19th Century.

One of the most successful women mathematicians known was Sonja-Krukovsky Kovalevsky, a Russian born in 1850. She too met prejudices against women in her country but by going to Germany and getting help from Weierstrass she became a famous mathematician. Sonja's brain, which had been preserved, was weighed and compared to the brain of Hermann von Helmholtz. It was found that, if relative body size was taken into account, the relative amount of brain tissue in the woman was greater (Osen,1974). This investigation had taken place as at that time there were attempts to show that man's brain was superior to that of woman's - part of the nature-nurture debate which survives even today.

Men also met opposition to studying mathematics. Augustus De Morgan (1806) met parental objection to his interest in mathematics during his early years but he rebelled and went to Trinity College Cambridge at a time of transition in the University's mathematical life - this was after Herschel had attended the college - and later became a professor of mathematics at University College, London. It was during this time that mathematics made great strides forward. The prospect of mathematics education improved in the first half of the 19th Century when mathematics teaching at Cambridge took on a new vigour, and a new type of secondary school arose which included mathematics as an important part of the curriculum.

Not only was the curriculum changing but the provision of schools was increasing too. Grammar and private schools were expensive and the 1820s saw the emergence of proprietary schools which were funded by committees. These schools were supported by the middle class whose wealth came from industry and commerce, and so it was inevitable that the curriculum demonstrated a utilitarian emphasis which had mathematics as an important part because of its usefulness, rather than other reasons such as the exercise of reasoning powers which De Morgan had seen as important and which is considered important today, although still not successfully taught in all schools. During the 19th Century the teaching of mathematics itself had many defects. Rote learning was the principal method used so pupils were not expected to understand the rules, only to apply them. De Morgan was aware of these defects and stressed the importance of language - being able to distinguish between different phrases and *to understand what* is being taught, and he also envisaged the teaching of numeration in different bases rather than sticking to the decimal system. It seems ironic that these two aspects are still being debated today, more than 150 years later.

The 1840s and 1850s saw the establishment of a growing number of schools for the poor but the mathematics content in the curriculum was very limited. Infant schools too had become recognised institutions with the foundation of the London Infant School Society in 1824. Again, with such rapid expansion in the provision of schools came the inevitable shortage of adequate teachers and there was at that time no satisfactory teacher-training system such as the one we know today. The first known course of vocational training to include practice in teaching was the Battersea three year course. Other colleges to train elementary teachers soon followed though these were mainly Church colleges. In the 1850s pupils from different social classes received different teaching dependent on their subsequent needs rather than their ability. A utilitarian emphasis was still the order of the day. If this influence has continued through to modern times and if teachers have low expectancy for girls' future careers then teachers may see mathematics as unimportant for girls and emphasise the teaching of arithmetic.

Evidence of thought on methods of teaching and child development appeared in the 19th Century. Tate (1854) believed that a good teacher varied his method according to each particular circumstance. He theorised that children pass through five stages of development each of which relate to what is taught and how it is taught, so he may be considered a forerunner of Piaget. Tate believed that children should learn nothing which they may afterwards have to unlearn.

Although provision of primary education and training of teachers developed, the growth of provision of secondary education for all pupils depended on the public schools to lead the way. Francis Buss who founded the North London Collegiate in 1850 and Dorothea Beale who became headmistress of the Ladies College at Cheltenham in 1857 created one of the first educational institutions since the Middle Ages in which girls were able to enjoy a similar curriculum to that of the boys.

Even so, the chances of a girl successfully pursuing a career was limited and this is demonstrated by a statement made by the Bristol School Board Management Committee in 1900 which said that ' *Women mistresses and assistants who marry must previously resign their appointment under the Board, as except under exceptional circumstances no married woman will in future be engaged as a permanent teacher by the Board.* ' Married women were encouraged to devote themselves to social work and good causes, and women at University or in the professions were expected to remain spinsters. These two groups of women - those who married, and those involved in careers - had a lack of respect for each other and may have encouraged the idea that intellectually able women were unmarriageable, an attitude which,- to some extent, still remains today. This forcing of married women to retire also exacerbated the problem of a shortage of women teachers.

Boys' public schools of the late 19th Century were founded to extend the opportunity of education to a large number of boys. The girls' schools shared a similar aim for their pupils but also had the difficult task of establishing the academic capabilities of women in competition with men, whilst gaining the approval and support of Victorian parents who exerted great influence on the schools. Miss Dorothea Beale, for example, while at Cheltenham wished to introduce mathematics but as parents did not wish it, to do so would have brought financial ruin on the school. The Taunton Schools Inquiry of 1868 pointed out that ' *We have much evidence showing the general indifference of parents to girls' education, both in itself and as compared to that of boys. The general deficiency in girls' education is stated with the utmost confidence by many witnesses of authority.* '. To a great extent therefore parental attitudes slowed the rate at which the curriculum for girls could be developed.

In 1863 the Cambridge local exams were opened to girls and gave impetus to the teaching of arithmetic and mathematics in girls' secondary schools, but it was not until after 1873 that mathematics became an integral part of the curriculum. The shortage of women mathematics teachers added to the problem of provision of mathematics education for girls but this also applied to boys' schools as there was also a shortage of men mathematics teachers. The monotonic increase in the school population ensured that supply of mathematics teachers has constantly been inadequate.

The Elementary Education Act of 1870 led to the establishment of a state system of elementary education in Britain. In the act no distinction of any kind was made between boys and girls - all were called children and subjected to the same rules and although, at first, arithmetic was taught to both sexes, this equal treatment was short-lived. In 1888, the Royal Commission on the Elementary Education Acts reported that the girls' curriculum with regard to arithmetic should be modified as 'they spend so much time on needlework that less time could be devoted to arithmetic' - again evidence of a utilitarian approach.

Following this Act there came the establishment of higher-elementary schools where children could go if their parents could afford to keep them in education for longer than the compulsory age. These schools adopted a technical and scientific curriculum.

2.6 Women and Mathematics in the 20th Century.

The Act of 1902 led to the establishment of a state system of secondary education with the result that two types of school existed - one mainly scientific and one with only one third of the curriculum devoted to science. The Rules of the Curriculum formulated in 1904 sought to remedy this imbalance but even so it was stressed that in girls' schools the hours devoted to mathematics and science could be reduced to one third of the total time. As mathematics teachers generally had poor qualifications and little experience text-book teaching was the common classroom practice and given the emphasis in teaching to pass exams, mathematics education was certainly inadequate according to present day criteria. As the curriculum developed to take in a wider range of subjects the importance of mathematics education was again questioned and in the 1912 report on the teaching of mathematics it was noted that there were many objections for mathematics to be viewed as important for girls views such that mathematics would be uninteresting and unuseful to girls and therefore would put undue strain on them. Miss Gwatkin, headmistress of Queen Mary High School in Liverpool, presented a case against these objections, stating that girls benefited from studying mathematics because it was an aid in developing clear and independent thought. She stressed the importance of teaching method and style rather than reproduction of correct answers stating that girls tend to reproduce rather than produce whereas boys tend to go off to a tangent, and therefore teachers needed to be aware of the different needs of the sexes. Echoes of this argument can still be found in the debates of the 1980s.

Differences in provision for the sexes was to continue for some time. From 1880 onwards the Board of Education handbooks of suggestions for the guidance of teachers proposed that girls should deal. with detailed accounts accompanying shopping and housekeeping while boys established, by experimental methods, some of the more important theorems of elementary geometry. Assuming these suggestions were implemented by the schools it is not surprising that the 1923 Consultative Committee of the Board of Education noted that out of 230 Advanced courses in mathematics and science provided in secondary schools, less than one quarter were in girls' schools. It was also claimed that ' *the present degree of girls inferiority in this subject should not be regarded as permanent, being partly to unskilful teaching of an old-fashioned kind and partly an impression among parents, which has influenced the timetable that mathematics is unsuitable for girls* '. No referral was made to the earlier handbooks of suggestions before making this inference.

Very little change occurred in the curriculum of secondary mathematics during the inter-war years. However, the Hadow Report of 1926 recommended post-primary education for all children and among other things stressed the importance of practical work in mathematics. Sixty-four years later, the Cockcroft Report of 1982 was still making the same recommendation.

It was 1937 before the educational needs of girls and boys was regarded as similar to each other. The report suggested that there were greater differences within the sexes than between the sexes. However, in drawing up the curriculum the importance of pupils' requirements for future working roles was stressed rather greater than the similar intellectual needs of the different sexes. Girls were viewed as non-career and potential mothers and so while a utilitarian approach to education prevailed there was little provision of mathematics education for girls.

The pioneers of education for girls in terms of their intellectual needs were quoted as being ' *concerned with one thing and one thing only - to make available for girls the best education then known. They wanted to learn, and to enable other girls and women to learn, Latin and Greek and Mathematics, not because boys learnt them, but because they were in themselves good things to learn* ' (The Year Book of Education,1932). The main concern was for the free and full development of girls' potential - there was no interest in the argument regarding the equality of the mental powers of the sexes. However, to get access to University and the professions it was necessary to demonstrate to 'men in authority' that their academic achievements equalled those of the boys'. This was to prove difficult as the attitude of one Oxford don, Marshall (1896) demonstrated when he wrote '*As regards lectures, I consider my first duty is to Members of the University and consequently endeavour to lecture as though men only were present ... Women's presence in the class prevents men from speaking freely either in answering or asking questions*'.

It is likely that if more girls and boys had been educated in co-educational schools, attitudes at University level might have changed more rapidly than they did. University intake came from the Grammar schools but as Grammar schools for boys came into existence first and girls' schools were founded later in an effort to give girls an equal opportunity, the sexes remained completely separated. Most maintained elementary schools were co-educational and so senior elementary schools were also usually co-educational. After 1944 the tendency was to build co-educational establishments, but where overcrowding occurred a second school would be built and the sexes split between the two buildings leading once more to single-sex schools. Thus the physical separation of the sexes was generally complete at senior level, and the lack of experienced female mathematics teachers meant that girls had poorer tuition in mathematics than did boys.

Following the 1944 Education Act which made secondary education compulsory, most authorities adopted the 'tripartite' system of Grammar, Modern and Technical schools. Thus was established the educational divide at 11 years of age not only by sex but by ability too. Increasing interest in the school curriculum resulted in the development of 'Modern mathematics' with an idea of stressing mathematical ideas and principles in a form suitable for modern developments. This development of modern mathematics took place at a time when setting and streaming was encouraged. Teachers were used to whole class teaching, emphasising numeracy and literacy, and research which questioned this approach was slow to be accepted by the teaching profession. At this period several books by Piaget appeared in the English translation but it was 20 years later before his ideas, particularly his 'stages' of children's development, were taken up on any scale. Susan Isaacs work (1933) led to a child-centred and 'Progressive' approach to education being recommended 'n the 1931 Report on the Primary School by the Consultative Committee (Hadow,1931), but it was much later that schools began to respond to these suggested approaches.

After the 1944 Act the 11+ system became the dominant factor affecting teaching in primary schools, with parents putting extreme pressure on the teachers to train the children towards passing the exam. This parental pressure, inevitably, influenced the teacher style and organisation in the classroom and mathematics was taught in a very limited way - there was little emphasis on practical work. The move towards a comprehensive system of education grew during the 1960s with the 11+ exam system being seen to lead to unequal opportunities. As a result of this secondary reorganisation the 'Middle' school era came into being as part of the 1964 Education Act. But authorities differed in the age ranges to be accommodated by these middle schools; some were 9 to 13, others 8 to 12 or 11 to 14. These differences in age range still exist today and are still changing (e.g. currently Leicester is changing some of its 11 to 14 high schools to 10+ schools). The change to comprehensive education and removal of the eleven plus examination has reduced the pressures on primary teachers and this has led to changes in teaching style and classroom organisation. During the 1970s streaming virtually disappeared and also different methods of teaching other than formal class teaching began to be used to a greater extent. The pressure of exams was confined to the upper schools.

Meanwhile the supply of teachers has failed to keep pace with the expansion of the education system. With the dawn of the computer age taking an increasing proportion of mathematics graduates into industry, schools have been left with an acute shortage of qualified mathematics teachers and this has remained the case up until the present.

The 1960s also saw an increase in in-service to enable teachers to keep in touch with new developments. A main source of this in-service was provided by Teachers' Centres, some of which supported general subjects while others specialised in only one subject such as mathematics. The Schools Council in 1967 saw the centres as a place where teachers would meet on a voluntary basis to discuss and focus on particular interests. To be effective in improving the mathematics curriculum the centres would have to involve the majority of teachers from local schools. But Howson (1975) noted that one of the more successful mathematics centres involved only 10% of the total number of local teachers. On this basis, Howson put the argument that in-service training should be school-based whereby the whole staff of a school would work together on issues which were relevant to that school.

The need for in-service of primary teachers, as identified by Ward (1979) was due partly to a poor attitude and lack of confidence related to the teaching of mathematics. Initial training of primary teachers failed to give these teachers the confidence they needed. Following the James Report (Great Britain, D.E.S., 1972) initial teacher training began to change from 3-year certificate courses to become all-graduate courses. With this change one might expect that confidence and positive attitudes in mathematics teachers would improve.

To establish a degree course in education a fourth year was added to the three-year college course and a B.Ed was awarded to successful students. An investigation by Lumb (1974) found poor mathematical skills in the new B.Ed students, with 86.4% of them failing to score on any 'modern' mathematics questions. Thus improvement in attitude and confidence in teaching mathematics did not take place.

2.7 Women and Mathematics at the Present Time.

The period 1968 to 1980 saw many educational reforms. With the political parties debating as to whether the Grammar/secondary modern school system or the comprehensive system should be implemented, many teachers felt unsure as to which system they would be working in the future. Arguments about the curriculum came second in importance to the issue of comprehensive schooling. Mathematical texts tended to be written by teachers for children in their own class at that particular time and little attention was paid to theoretical arguments concerning development of the mathematics curriculum.

The CSE system was introduced as an exam for those children who didn't attempt GCE. Thus secondary modern schools took up the C.S.E while Grammar schools kept mainly to G.C.E. The general public began to associate C.S.E. with the lower achievement of secondary modern pupils. Comprehensive schools took up both exams but more girls were entered for the C.S.E. than the G.C.E. whereas many boys were entered for both exams. Thus on attaining school leaving age, girls who, in the main, were limited to C.S.E. qualifications were faced with prospective employers who were likely to associate C.S.E. with low achievement.

As the number of comprehensive schools increased, the C.S.E/G.C.E. overlap within the schools led to mixed-ability teaching and issues relating to the content of the mathematics curriculum became a focus of the teachers once more.

Many new mathematics projects have been developed in recent years such as SMP and Nuffield (5 to 13 years) bringing a more open approach to curriculum development with an emphasis on providing practical experience but with new employment patterns emerging as a result of technological advancements and with social changes in family compositions, the purpose of mathematics education in schools yet again was questioned and led to the Cockcroft Report (1982) which reported a lack of confidence amongst people with regard to mathematics. The report paid a great deal of attention to differences in performance between girls and boys in mathematics and it was stressed that more research in Britain is needed so that the performance of girls can be improved to cater for the needs of the modern day.

2.8 Summary.

To summarise, it appears that the situation as it is today arose through the interaction of many complex factors. The science of mathematics developed from astronomy which has religious foundations. This resulted in mathematics education being available for a few men only.

Initially, attitudes of society were against women being educated at all, rather than against women learning mathematics. The other factor in attitudes was society's general reluctance to see mathematics as a worthwhile subject to teach to either boys or girls. As boys' educational opportunities developed ahead in time to those of the girls' it was inevitable that the attitude against girls learning mathematics should continue for some time after the acceptance of mathematics education for boys.

The absence of mathematics and science in the school's curriculum inevitably contributed to the present day abundance of students educated in 'arts' subjects, and shortage of students in the 'sciences'. Because of the shortage of teachers with mathematical knowledge, there was little or no provision for teaching mathematics in school. When eventually mathematics was taught the approach was utilitarian based on the needs for future careers. The development of mathematics has been such that the supply of suitable mathematics teachers has constantly failed to keep up with demand, and this has been exacerbated by the rise in the school population. The history of single-sex schools meant that girls, who tended to be taught by women teachers, had even fewer well-qualified mathematics specialists than did the boys.

The pressure of exams affected teaching styles employed in the schools and subsequently prevented the development of mathematical skills in the way which the Cockcroft Committee reported as being desirable. Teachers were used to teaching according to the future needs of the pupils which meant that lower social classes (who were expected to go into unskilled jobs) and girls, who were expected to become housewives, missed out in the higher cognitive elements of mathematics, the emphasis being on arithmetical computation.

Girls were often given the choice between a career or marriage, and this may have contributed to an attitude of 'clever' girls being unmarriageable, or that ' boys don't like *girls who can do mathematics* '.

The influence of parents, whether positive or negative, on their children and on the schools appears to have been powerful throughout history and as girls were considered future housewives and mothers it was inevitable that parents would emphasise education for boys more than for girls. With technical advances, parents saw mathematics as necessary for careers and so encouraged the study of mathematics by their sons.

Perhaps the most disturbing fact was the reluctance of teachers to take notice of research and to implement changes as a result of such findings. Some suggestions for change which were made in reports many years ago are still being urged today. As changes to improve girls' education in mathematics have been advocated over many years, it is necessary to look at the situation today to see which, if any, of the changes are taking or have taken place, and what further changes would be conducive to improvement of the mathematical achievement of girls and ultimately the supply of competent and specialist mathematicians.

CHAPTER 3

THE EVIDENCE OF GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT.

3.1 Achievement.

As discussed in chapter 2, the term 'underachievement' is a problematic one since it is difficult to demonstrate that a child is underachieving until he/she demonstrates that he/she can achieve more by actually doing so. Achievement may be expressed in terms of skills which are demonstrated within the classroom situation, or in terms of scores obtained in mathematical assessment tests, or in terms of the number of qualifications in mathematics which are obtained. If girls' mean test scores are generally lower, within the population studied, than boys' mean test scores in mathematics, then underachievement of girls in mathematics may be defined as girls' lower achievement compared to that of boys' in mathematical tests. Similarly in any one population studied, if the percentage of boys obtaining a qualification in mathematics is greater than the percentage of girls obtaining a qualification in mathematics, then underachievement of girls in mathematics may be defined as girls' lower achievement compared to that of boys in obtaining a mathematical qualification. Using these definitions described above, the following section examines the evidence for gender differences in results of public examinations in mathematics - the CSE, the GCE, and higher education examinations.

The number of girls achieving success in higher level mathematics exams has nearly always been lower than the number of boys who are successful. For the CSE exam the performance of girls can be examined as the number of girls' grade 1 passes expressed as a percentage of the total passes. These results are shown in Table 3.1.

TABLE 3.1 GIRLS PERFORMANCE IN MATHEMATICS AS A PERCENTAGE OF TOTAL PASSES IN CSE MATHS.

YEAR	1967	1971	1972	1974	1976	1977	1978
%	43.3	46.7	47.1	48.3	48.4	49.3	50.2

SOURCE: Statistics of Education 1978, 79, HMSO

The girls' share of CSE passes has steadily increased from 43.3% in 1967 to about half of the passes in 1978. Thus girls' underachievement in CSE appears to have disappeared in more recent years. However, it is possible that more girls than boys were entered for the exam in which case a 50% share of the passes would still represent underachievement. The statistics for 1978, show that 208600 girls compared to 206350 boys were entered for the CSE exam and so for an equal share of grade 1 passes one would expect girls to have 50.2% which is exactly the figure published (Source: DES 10% Leavers' Survey). Thus underachievement of girls in CSE had fallen by 1978. The corresponding GCE 'O' level figures, however, are not so satisfactory. The number of girls' passes at grades A-C of GCE 'O' level exams can be shown as a percentage of total passes and this data is given in Table 3.2.

TABLE 3.2 GIRLS' PERFORMANCE IN MATHEMATICS AS A PERCENTAGE OF TOTAL PASSES IN 'O' LEVEL

YEAR	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
%	33.3	35.6	35.2	35.8	36.6	36.5	36.4	36.9	36.8	39.6	40.9

The girls' share of 'O' level passes has increased from 33.3% in 1967 to 40.9% in 1979. When the number of entries for 1978 are considered, 100610 girls were entered for 'O' level compared to 130050 boys so one would expect girls to have a 43.6% share of the passes compared to the actual pass rate of 39.6%. Similarly, considering the figures for 1979, girls could expect a share of 44.29% of the passes but only received 40.9%. Thus girls do appear to have 'underachieved' in the 'O' level results of 1978 and 1979.

In a similar manner, the percentage of girls passes in 'A' level exams can be shown as a percentage of total passes. These figures are to be found in Table 3.3.

TABLE 3.3 GIRLS' PERFORMANCE IN MATHEMATICS AS A PERCENTAGE OF TOTAL PASSES IN 'A' LEVEL

YEAR	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978
%	16.3	19.3	20.7	21.6	22.9	22.1	22.4	21.2	22.5	22.9

The girls' share of 'A' level passes increased from 16.3% in 1967 to 22.9% in 1978. Looking at the number of entries for 1978, only 12350 girls were entered for 'A' level compared to 34670 boys, so girls could expect a share of 26.25% of the passes yet received 22.9%. Although these figures favour the boys in terms of achievement, the number of boys and girls is very large and therefore the difference between the sexes in pass rate is not large enough to be significant.

It appears therefore that by 1978/79 girls were doing as well as the boys at CSE level mathematics but underachieving at 'O' and 'A' level in terms of the proportion of girls compared to boys who are entered for the exams rather than in terms of the pass rate. The trend whereby males achieve proportionately greater success in mathematics continues to even higher academic levels. This is illustrated by the following figures in Table 3.4 showing the ratio of males to females gaining mathematical qualifications at various levels.

ABLE 3.4 THE RATIO OF MALES TO FEMALES GAINING QUALIFICATIONS IN MATHEMATICS

	CSE	'O'	'A'	1st Degree	Research	Ph.D.
MATHS	1.0	1.5	3.8	2.6	8.0	9.7
ALL SUBJECTS	1.1	1.0	1.4	2.0	4.1	6.3

SOURCE: DES Education Survey, no 21, HMSO, 1975.

It is clear from these figures that although males and females do as well as each other at CSE level, there is a steady increases in ratio in favour of the boys as the level of qualifications increase, both in mathematics and in all subjects. However, the increase in ratio is more dramatic in mathematics, there being 9.7 males to every female with a Ph.D in mathematics compared to 6.3 males to every female with a Ph.D when all subjects are considered.

One striking feature of the statistics mentioned so far has been the greater number of boys being entered for higher levels of mathematics compared to the number of girls. This could, of course, be due to a greater number of boys reaching that age. When school leavers' figures are examined, however, it transpires that in 1978, 373570 girls compared to 394,890 boys left school (i.e. girls were 48.6% of the leavers). Similarly in 1979, 381610 girls compared to 399630 boys left school (i.e.

girls were 48.8% of the leavers). Thus it appears that a disproportionate number of boys were entered for higher levels of mathematics compared to girls.

An ILEA study looked at similar figures for exams of Summer 1980 (ILEA,1982). Results for 15-16 year old pupils only were included in the study, and although overall more girls were entered for a mathematics exam (of any kind) than boys, more boys had been entered for 'O' level. In English, however, the opposite was true. The ILEA compared their findings with those of the DES 1979 Statistics of Education (DES,1981) and also with Aspects of Secondary Education in England (Great Britain,DES,1979). They found a similar pattern and concluded, therefore, that the sex difference in exam entries was a national practice and not just a regional phenomenon.

The differences between mathematics and English are also interesting. In the 1979 'O' level exams, although only 40.9% of passes in mathematics were achieved by girls, in English the corresponding figure was 59.1% . This trend in favour of girls in English continues at 'A' level too. In 1978 'A' levels, only 22.9% of mathematics passes were obtained by girls, yet in English literature 68.4% of all successful candidates were girls, a mammouth superiority. There seems no obvious reason to explain these opposite trends in the results between the sexes in mathematics and English.

Evidence for girls' poor levels of achievement in mathematics is not, however, confined to results of public examinations. The International Study of Achievement in Mathematics (IEA) conducted a study of mathematics achievement in twelve countries during 1964. Results showed that overall, males performed better in relation to girls on both computation and on verbal problems (Husen,1967).

The findings of other studies have not been as conclusive. An American review of 36 studies (Fennema,1974) found little evidence of sex-differences either before or during secondary education but there was a trend for males to excel in higher level cognitive tasks and females in lower cognitive tasks. A few years later, Fennema (1977) found that a few sex differences did occur from the 7th grade onwards and most of these favoured males. Schonberger (1978) also reviewed the literature but limited his study to problem solving. He concluded that superior male performance rarely occurred and then usually affected only higher-ability students and involved certain types of problems.

Another American review of research on sex-differences in mathematics was undertaken by Maccoby and Jacklin (1974). They found no sex differences at pre-school age or in numerical operations and concepts during the early schools years. However it should be noted that testing of such young children has methodological problems and so investigations of this type have so far been limited. Most of the studies reviewed found no sex differences up to adolescence, but when differences did begin to occur they consistently favoured boys up to adulthood (e.g.Hilton and Bergland,1974; Keating and Stanley,1972; Droege,1967; Backman.1972; Very,1967). Visual spatial skills have often been linked by researchers to mathematical ability.The research literature suggests similar results to those for sex-differences in mathematics (i.e. virtually no sex differences were found up to age 13-14 years and then boys were consistently higher scorers on tests of visual spatial skills (Nash,1973; Stafford,1961; Backman,1972). Similar findings have also been reported for spatial tasks which involved embedded figures, but when verbal skills studies were reviewed no consistent findings have been found. Where sex differences did occur, after adolescence, girls tended to be the better performers but a great many tests failed to find any sex differences at all in verbal skills.

The Assessment of Performance Unit (APU) of the Department of Education and Science investigated performance in 15 mathematics curriculum areas (APU,1980). The study reported that, in 1978, 15 year old boys scored higher than girls in all of the areas tested, the results reaching significance in 11 out of the 15 areas. In contrast, a study of 11 year olds revealed few significant differences between the sexes (Foxman et al,1980).

It is interesting to consider the APU study in greater detail. The APU first mathematics survey involved about 13000 pupils. Questions for the whole study were split between several sub-tests such that at least one question from each mathematical concept area was included in each test. To obtain the sample of pupils for the testing, a selection of schools was selected from different areas of Britain, and from each school a selection of pupils of the relevant age group were chosen at random for the testing. This method of sampling is known as a two-stage sampling technique. Each question was answered by approximately 1500 pupils. The second survey (1981) involved about 14500 pupils, with each question answered by 1000 pupils. Commenting on the fact that the results were statistically significant the APU drew attention to the need to interpret the results carefully since with very large samples even small differences can reach significance level.

To summarise, sex-differences in achievement in mathematics are to be found in the results of public examinations at higher levels, the biggest difference being in the number of boys compared to girls who enter for these exams rather than the relatively poorer performance of girls compared to boys. The various reviews of research studies show a degree of superior performance by boys after adolescence but not exclusively so.

Part of the initial concern about underachievement of girls in mathematics appears to have arisen because the studies published were mainly those where significant differences had been found. It was only after interest in the area had developed that these other insignificant results began to appear in journals, redressing the balance somewhat and suggesting that the underachievement of girls was not quite as serious as some of the more vociferous critics of the educational system originally argued.

There appears to be no evidence of sex differences in mathematics achievement in the primary years, and in the secondary years differences appear to be limited to pupils who study higher mathematics. Superior performance by boys in tests has been inconsistent but evidence suggests that when it has occurred it is limited to certain topic areas within mathematics.

Although therefore, the extent of underachievement is not as great as originally suggested, these findings still raise two important questions for further consideration by researchers,

1) why do so few girls study mathematics at higher levels, and
2) is the poorer performance of those who study mathematics at these higher levels related to difficulty in certain areas of mathematics, or is it related to some aspect of their educational history ?

3.2 Test Item Content and Errors.

The APU (1982) reported that boys tend to overrate the ease of mathematics problems in comparison with girls. This, together with the fact that correlations between ratings of difficulty and performance were higher than ratings of performance with enjoyment or utility might suggest that the lack of success on items considered difficult by girls account for their relatively poorer performance in mathematics tests. It is interesting therefore to examine the items that girls find difficult.

Girls generally are thought to perform well in arithmetic and algebra (Armstrong,1980; Preece,1979) while boys do better on visual spatial and problem solving, place value and measurement (Ward,1979). The major discrepencies in performance arise in two general areas; one involving spatial ability and judgement, the other involving recall, and application of knowledge to a problem. Within these general areas there are specific topics e.g. geometry and measurement which appear to present consistent difficulty to girls.

APU primary reports showed that although boys did achieve better results in certain categories of mathematics, on the whole the performance of the two sexes differed very little. Freedman (1985) reporting on a Basic Numeracy Test looked at results of the five sub-tests involved and found that for four out of five tests the scores of girls and boys were very close. The one test which did show boys to have better performance had a high geometry content which is in line with findings of the three APU surveys (APU,1980,1981,1982). As a result, Freedman decided to look at the Basic Test sub-scales of similar item type, for example simple arithmetic, fractions, etc. Girls performed significantly better on simple addition and subtraction and on fractions; boys were better on decimal places, percentages, measures and square roots, area, volume and ratio. There was, however, a low number of items in each sub-scale and so the importance of these differences should not be overrated. Gender differences were significantly different over two or more years for both APU primary tests and the Basic Numeracy Test for the categories money, weight, temperature, length, area, volume and capacity; number concepts relating to decimals and fractions, applications of number, and rate and ratio, all favouring the boys, with computation of whole numbers and decimals favouring girls.

In the secondary APU surveys (1980,1981,1982), 8 out of a total of 15 categories favoured the boys (number concepts and applications, three measure categories, graphical algebra, descriptive geometry, and trigonometry). Is is interesting to note that the superiority of boys performance found by the APU was not due to a high number of girls scoring low marks. Rather it was because more boys than girls scored high marks and this resulted in a higher mean score for boys than for girls.

In a review of the literature on sex differences, Walden and Walkerdine (1985) reported that boys were significantly better on test items requiring spatial ability, and on more complex items requiring abstract thought and problem solving, while girls were better at rule-following (Shuard,1981; APU Surveys). Although the APU found girls remained better at computation into the secondary school, the boys had lessened the gap, and this could suggest that factors causing the differences in mathematics attainment are already operating in the primary school.

Walden and Walkerdine (1985), in an observational study, used audio and visual recordings of 11 to 12 year olds and 14 to 15 year olds when interviewing pupils following performance on a mathematics test. Responses to the test items were coded as right, wrong or not attempted. Their results overall, showed no sex differences in the number of questions answered either correctly, wrongly, or not at all but when the results were broken down by school, differences in the wrong and the unanswered categories were found. With the junior age children, out of 40 separate test items, only three showed significant sex differences. Walden et al then looked at secondary pupils in a similar way. Of 38 items only 4 showed significant sex differences. The main difference seemed to be a willingness to attempt a question, prompting the query, 'should we be looking for sex differences, or similarities ?'

Thus there is some evidence to show boys and girls differ in ability in some mathematical topics, boys in geometry and girls in computation; but not all studies have found these differences - some finding that differences were restricted to certain schools and not others, some studies finding no overall differences at all. It is difficult, however, to compare findings of one test with another as even two geometrical items, are unlikely to test exactly the same skills and knowledge as each other. A closer look at item content is necessary, including context and form of presentation before it is possible to say that poor performance of girls is restricted to certain mathematical topics.

There remains the question of why so few girls study mathematics at a high level. To answer this question requires extensive review of literature on social factors and this is presented in the following chapter.

CHAPTER 4

REVIEW OF THE LITERATURE ON GENDER DIFFERENCES IN MATHEMATICS.

4.1 Introduction.

As discussed in chapter one, one possible hypothesis to explain girls' underachievement in mathematics is that both choosing to study mathematics at 'A' level, and levels of mathematics achievement, are probably influenced, to a degree, by certain early experiences of pupils, including the resulting interaction between social rearing and biological factors. Numerous studies have investigated different variables which might be expected to have had such influence, but few conclusions have been possible as only one or two variables have been studied at a time with the same sample of the population. An interaction between several variables is now thought the most likely cause of underachievement of girls in mathematics but what these factors are and their role in the establishment of underachievement in mathematics remains to be discovered.

Evidence exists that shows mathematically gifted children develop at a very early age (3 to 5 years according to Krutetskii,1969). This together with the determination of some women to study mathematics and become famous mathematicians, even with considerable opposition from their parents and society, has led to theories which suggest heredity plays a role in determining mathematical ability. Higher test scores by males, and different correlations between scores for the child and same-sex and different-sex parents have also led some researchers to believe that mathematical abilities are carried by sex-linked recessive genes (Stafford,1972).

Other studies have emphasised the importance of a variety of cognitive and affective variables. Sherman (1979) lists seven such factors - general intelligence; verbal skills; confidence in learning mathematics; perceived attitude of mother, father, and teacher; perceived usefulness of mathematics; motivation; and attitude of mathematics as a male domain; and the study did find these cognitive and affective variables to be good predictors, for ninth graders, on later mathematics performance.

Some researchers have suggested that spatial skills could account for the sex differences which have been found in mathematics, but there is disagreement as to how important a factor these spatial skills are to mathematics performance. Weiner (1980) argues that spatial ability is crucial to mathematical skills particularly within the Piagetian approach i.e. action upon objects. Certainly the involvement of spatial skills in mathematics ability must be considered a possible source for sex-differences in performance as studies have shown boys to be superior in spatial abiltity from the age of 14 years (Bergan et al,1971; Silverman et al,1973) which is similar to findings for mathematics. Maccoby and Jacklin (1975) found a correlation of 0.5 between spatial skills and mathematics achievement, while Fennema and Sherman (1977) found a correlation of 0.48 between spatial visualisation and mathematics achievement which gives support to suggestions of a strong association between these two areas of ability. Fennema and Sherman (1977) also found high correlations between verbal skill and mathematics achievement, and between confidence in learning and mathematics ability (r=0.41).

Sherman (1967) has hypothesised that girls' lack of practice in developing spatial skills (owing to less participation in mathematics-type classes) affects girls' learning of mathematics, and that sex differences in mathematics can be accounted for by differences in spatial visualisation. She suggested, therefore, that it is not a genetic factor but a spatial visualisation factor which accounts for girls' underachievement in mathematics. The effect, on mathematics performance, of the number of mathematics-type courses followed in school was investigated in a study of eighth grade students (Sherman,1980). Sherman reported that where boys and girls both follow the same number of courses involving spatial skills their mathematics performance was different, so the number of courses taken cannot be the sole causal factor of gender differences.

Evidence of use of spatial skills to solve mathematics problems has been found by Krutetskii (1976) who found that individual children who were proficient mathematicians used different strategies in solving mathematics problems, some of which were designated as spatial, some that were not. And so there appears to be all sorts of thinking styles, some of which are irrelevant to spatial skills. Thus the debate continues on the influence of biological, cognitive and affective factors in relation to girls' apparent underachievement in mathematics. These factors will be considered in more depth.

4.2 Biological Influences.

4.21 SPATIAL ABILITY

Biological theories have tended to focus on spatial ability i.e. the ability to perceive and rearrange shapes of objects mentally. Correlations between children and their opposite sex parent in academic performance (Maccoby and Jacklin,1975) could indicate a recessive gene on the x-chromosome, and Bock and Kolakowski (1973) believed that the ability carried on this one chromosome can only be released when a certain level of the hormone testerone is present. However, Fennema (1975) reported that sex differences in spatial tasks do not appear in all cultures (e.g. Eskimos) which suggests that genetics alone may not be responsible for sex differences in performance. Therefore many questions are left unanswered and research is continuing in this area. Everyone has some degree of spatial ability and so the recessive gene cannot be the only factor. Maccoby and Jacklin (1975) suggested that genetic and cultural factors are interrelated with biological factors.

Spatial ability is usually tested by means of block designs, mazes and jigsaws, and Lips and Colwill (1978) noted that women have difficulty in these tasks. In Embedded Figures Tests (in which a figure is 'hidden' within another and needs to be recognised) performance of males has been found to be superior to performance of females but whether this involves spatial skills or analytic ability is debateable (Sherman,1967). When blind subjects were tested on tactual versions (Witkin and Goodenough,1976) no sex differences were found. The researchers therefore concluded that such differences only occur in the visual mode. Training in EFT has been found to eliminate these sex differences but the training didn't appear to generalise from one task to another (Maccoby and Jacklin,1974). McGee (1979) also found training to improve performance but the improvement was the same for both boys and girls - it had been assumed that if boys were reaching their mathematical asymptote then training would benefit girls more than boys. So there is some disagreement on the effect of training on the different sexes. Bigelow (1971) found no EFT sex differences up to 10 years of age, and when Conner and Serbin (1980) and Wattanawaha (1977) gave a variety of spatial tasks to adolescents, the context of the item was found to be important.

Some items showed male superiority, some did not, and this has obvious implications regarding item content of mathematics tests.

Werdelin (1958) found evidence to suggest that spatial visualisation was positively related to mathematical reasoning but negatively related to computation factors therefore it could be that early emphasis on computation skills affects the development of spatial skills to the detriment of mathematical reasoning. Hence girls, who are considered superior on computation, would be delayed or prevented from acquiring the skills they needed for further mathematics.

The aetiology of sex differences in spatial ability is therefore unclear and although some evidence exists of a genetic factor being involved, there is also evidence that whatever genetic potential does exist it is affected by training and experience. Even so, the magnitude of the effect of training and experience could well be influenced by the genetic factor in a developmental way. If a child has to reach a particular stage of cognitive development for certain training to take effect, then training before this stage has been reached would be ineffective. It might be that girls develop more slowly than boys in these areas and that teachers are attempting to train them in such skills at an inappropriate time.

4.22 DEVELOPMENTAL STAGES

Various theorists have attempted to conceptualise mathematical development in terms of 'stages' (Piaget,1952; Piaget et al,1960; Lovell,1968; Skemp,1971). Piaget maintained that children pass through three stages in attaining the concept of number - 1) a non-conservation stage, 2) a transitional stage, and 3) a conservation stage. Piaget likewise viewed development of geometric concepts as - 1) attainment of topological concepts, 2) attainment of projective concepts, and 3) attainment of Euclidean concepts (Piaget, Inhelder and Szeminska,1960). Research evidence does point to age trends in mathematics development but the wide differences in rate of development between children suggests that the actual situation may be more complex than Piaget's theories suggest (Dodwell,1960; Sealey,1960; Lovell,1968).

Klausmeiuer and Wiersma (1964) also described the early acquisition of concepts in terms of a developmental sequence - initially children classify objects solely in terms of obvious concrete characteristics. Then develops the IDENTITY stage when an object can be recognised from various angles. This is then followed by the CLASSIFICATORY stage when the child can group different instances of a concept. Lastly, during the FORMAL stage, the basis for the classification can be understood. This is similar to Piaget's stages of development with - 1) the Sensori-Motor stage (0-2 years) when the child thinks through interaction with the environment, then 2) the Pre-operational stage (2-7 years) which is a time of concrete concepts when symbols are used to represent objects or events in the surroundings, and 3) the stage of Concrete Operations (7-11 years) when the child can make mental representations. Finally there is 4) the Formal Operations stage (11+ years) which it is necessary to reach before a child can formulate hypotheses.

There are however, many critics of Piaget's theories on stages (e.g.Brown and Desforge,1977, Desforge and Brown,1979; Donaldson,1978). Shayer (1979) has described Piaget's theories in terms of tiers. The first tier consists of descriptive accounts of children's behaviour under experimental conditions. The results of these experimental tasks have been replicated and are relatively uncontroversial. The second tier concerns the interpretation of and subsequent classification of these behaviours into developmental stages. It is this second tier which has been the subject of criticism from other researchers. For example, Donaldson (1978) presented a variation of one of Piaget's tasks on class inclusion and found that by making the task more specific to the age of the subjects who were performing on the task, greater success rates were achieved. Donaldson pointed out that this second task demonstrates the sensitivity of experimental tasks to variation.

Other criticisms have centred on the ages specified for each of Piaget's developmental stages. For example, various studies have attempted to show that the Piagetian performance can be achieved earlier than that suggested by Piaget (Gelman,1972; Bryant and Trabasso,1971; Donaldson,1978). Inhelder et al (1974) used training sessions and found that children who were on the threshold of a new stage could be improved, but those below could not. Pascual-Leone (1976) showed that while training can improve performance on a particular task, it might not actually alter the cognitive level. Thus it does not seem that girls' cognitive development in mathematics skills could be accelerated by such training.

Lovell (1968) has found that pupils of IQ 140+ do not reach the periods of concrete operational or formal operational thought appreciably earlier than children of average intelligence so earlier development of cognitive 'tools' may be ineffective in improving later performance. At both of these stages however, the thought patterns of gifted children were much more flexible, being applied to a greater variety of situations than in the case of children of average ability, so that an emphasis on flexible thinking might be beneficial to girls.

Changes in mathematical ability with age have been widely documented (Krutetskii,1969; Very,1967; Dye and Very,1968; Geng and Mehl,1969). However, as a child gets older, s/he also develops physically and some researchers have suggested a link between mathematics achievement and levels of certain hormones which accompany this physical maturing. The influence of hormones on the levels of performance in mathematics will now be considered.

4.23 INFLUENCE OF HORMONES

In a study by Waber (1977) girls and boys of 10 to 16 years old were classified by a medical exam as early or late maturers and were tested for verbal ability, spatial ability, and lateralisation of speech perception. Late-maturing adolescents, regardless of gender, performed better on tests of spatial ability than did early-maturing adolescents. This seems to coincide with the fact that boys, who mature later than girls, also tend to be better than girls at spatial tasks. Waber (1977) suggested that maturation rate is affected by hormones which influence the development of brain functions hence helping to determine the level of spatial ability. She suggested that late maturers show more hemispheric specialisation of ability than early maturers and that it is this difference in specialisation that promotes the effect of maturation rate on spatial ability. It could be, of course, that certain tasks (practice, etc.) influence brain specialisation.

Broverman, Klaiber and Vogel (1968) suggested that male and female sex hormones affect intellectual performance by interacting differently with transmitter substances in the brain resulting in development of skills in different types of task. But this idea has little empirical support and Parlee (1972) has written an extensive critique of the Broverman hypothesis. There is, however, some evidence to suggest that hormone levels do affect spatial skills but not other cognitive abilities, and as hormone production is linked to maturation it would seem plausible to consider it as being connected to the adolescent onset of sex differences in mathematics performance.

4.24 THEORY RELATED TO NERVOUS PROCESSES

A somewhat different biological theory has been put forward by Krutetskii (1969) who suggested that mathematical stimuli and activities affect the capacity or strength of nervous processes in a different way from other kinds of stimuli. The nervous systems of some people e.g. males may be more sensitive to mathematical stimuli i.e. their brains oriented that way and therefore this would account for the different performance between high and low achievers in mathematics.

4.25 SUMMARY

In summary, a large number of variables have been considered as contributing to sex differences in mathematical performance. Those who argue that biological factors play a role in determining these differences between boys and girls have to accept that these factors are inadequate by themselves to explain gender differences as it is argued that environmental factors can also influence biological changes. Intellectual development may depend on genetic potential but the effect of genetics is likely to be diminutive compared to the pressures of social and cultural factors such as the environment, parental encouragement, and teacher influence. Biological differences in relation to mathematical ability, if they exist, can be accommodated but not changed by the teacher and therefore the present study places emphasis on the examination of cultural pressures and socialisation processes, knowledge of which are of importance to the class teacher in their effect on teaching methods and processes within the classroom.

All experiences that children undergo have some effect on the subsequent learning and achievement levels and all of these experiences may contribute in some way to the underachievement of girls in mathematics. The following section of this study considers the teaching and learning strategies employed within the classroom and the possible differential effect of different teaching methods for girls and boys.

4.3 Learning Theories and their Effect on Achievement in Mathematics.

Theories on cognitive development have influenced the methods teachers use to promote learning, even when there has been no conclusive evidence relating to the effectiveness of these methods. Examples of such influence concern Froebel who, in the 1890s introduced a theory of 'natural development' and 'spontaneity' while in the 1900s Maria Montessori emphasised the importance of structured learning and individualisation. The fostering of cognitive growth through the manipulation of concrete things and discovery came from Piaget's theories of developmental stages as adapted and extended by Bruner (Bruner et al,1966). Drill, rote and discovery have, according to different theoretical perspectives, been advocated as teaching methods in recent years. Although advocates of these approaches have claimed some success, not all children appear to have benefited to the same degree (Richards and Bolton,1971). It could be therefore, that certain teaching methods suit one of the sexes more than the other leading to achievement differences across the whole curriculum, particularly in English and in mathematics. Evidence related to the success of different teaching methods needs to be considered in detail here before the implications for gender differences in mathematics achievement can be evaluated. If, for example, girls reach a developmental stage at a different age to boys then, in a class containing a single year age group of boys and girls, a teacher who adopts a particular method of teaching may find the method is likely to be unsuitable for one of the sexes.

4.31 DISCOVERY LEARNING

Peters (1969) has questioned the value of discovery methods arguing that there is little evidence to suggest that discovery has been more successful than any other method. Ausubel (1968) suggests there has been an over-emphasis on discovery methods and although useful, such methods were time-consuming and had enjoyed limited success in that not all children are able to 'discover'. As Inhelder and Piaget have pointed out, young children tend to be subjective and jump to conclusions (Inhelder & Piaget, 1958). To overcome the problem of failure to discover it has been suggested that the teacher should give help to 'guide' discovery, but there has been a general disagreement over the amount of intervention that should take place by the teacher. None of these writers have considered the possibility that girls might react differently to boys under different teaching conditions. Research is therefore needed on this issue.

Both Bruner and Sealey have advocated the use of discovery learning to encourage mental activity (i.e. to encourage pupil's willingness to ask questions and to search for answers themselves). Girls are considered to lack both of these qualities in the mathematics classroom. During mathematics lessons pupils were expected to discover principles by doing practical work and the teacher's intervention was considered unnecessary, but Bruner himself saw guided learning as an ideal method whereby students are free to explore but teachers still have an active role in guiding the learning and in organising the curriculum to suit the intellectual level of the pupils (Bruner et al, 1966; Sealey, 1960). Some researchers have reported teachers to hold the view that girls, generally, have a lower intellectual level in mathematics than boys. If this is true, then teachers would, according to Bruner's suggested method of teaching, organise the curriculum in such a way to suit the perceived lower intellectual level of girls and higher intellectual level of boys. Hence the two sexes would receive differential treatment by the teacher. Discovery learning (i.e. examples followed by a rule) has been claimed to be more effective with 12 year olds than a method of rule followed by examples (Land & Bishop, 1967, 1968, 1969). Worthen (1968) has also investigated the effectiveness of these two methods of learning. Sixteen classes of 11+ year olds were involved in the study. Over a six week period, work on directed numbers and indices was taught by two methods 1) Expository (Rule → examples), and 2) Discovery (structured sequence of examples). Eight teachers used both methods but with different classes, and observation techniques and a pupil questionnaire were used to ensure conformity of use of each method. Using the scores on *achievement tests* as a measure of performance it was found that discovery method resulted in inferior performance on an immediate post-training test, but resulted in superior performance on the retention and transfer tests. However no data was presented comparing girls' performance to that of boys' performance.

Roughead and Scandura (1968) suggested that the superiority of discovery learning relates to learning how to approach problems. They argued that this skill could be taught by the expository method (and their study supported this view). There remains the danger that a pupil might be reluctant to tackle a problem for which no general rule or strategy had been taught and that attitudes might deteriorate as a result. Scandura (1969) and Anthony (1973) both stated the inhibiting effects of 'failing' to discover and suggested that pupils need monitoring closely in order that guidance from the teacher is both appropriate and effective. All studies mentioned above have failed to compare the effectiveness of discovery learning for boys and girls separately, and yet, as will be shown later, girls are thought to be affected by a lack of self confidence and a greater fear of failure. Thus monitoring by the teacher should be of great importance for improvement of girls' performance in discovery learning.

Girls are also thought to be affected more than boys by other personality dimensions and research studies have suggested that personality dimensions may affect the suitability of discovery or exposition for particular pupils. Trown 1970), in a study of 12 year old pupils, investigated performance of the pupils on mathematical tests following some teaching by discovery methods and some teaching by expository methods of learning. The results suggested that extraverts were handicapped by the Rules → Examples method.

In a further study, Trown and Leith (1975) used the two methods of discovery or exposition on directed numbers with a sample of 10 year old pupils and found that highly anxious children had poor performance when using the discovery method but not when using the exposition method. Thus if, as suggested, girls are anxious and introverted then exposition methods would be best suited to their learning whereas if boys are extroverted and not anxious then discovery methods would be best suited to their learning. The argument for separate-sex classes would thus be a strong one.

4.32 DRILL AND ROTE METHODS

The effectiveness of drill and rote methods compared to discovery has also been studied (Ashlock and Herman,1970; Brownell and Chazal,1935). Many studies have reported the effectiveness of drill as a teaching strategy for arithmetic. As there is evidence that girls produce superior performances in arithmetic compared to boys it could be either that the drill method has been used successfully with girls or that it hasn't been used but would help boys if it was. Brownell investigated 63 children of 8 years of age and found that all of the pupils improved in efficiency in terms of their speed and their accuracy. He interviewed the children as he was also concerned with the extent of their understanding. He found that 45% of the sample used immediate recall, 20% guessed, 20% counted, and 15% used indirect solutions. These figures were the same before and after drill sessions. Thus drill made no contribution to growth in quantitative thinking, and would appear not to encourage girls' improvement in cognitive growth. Looking at more recent research Williams (1971) found that meaningful learning was favoured over drill as it aided retention and transfer to new tasks and affected attitudes favourably. All of these variables are considered particularly to affect girls' performance in mathematics.

Carl Rogers (1969) has criticised any approach to education which encourages competition, including drill and rote methods of learning. Rogers believes that competition has resulted in many children experiencing failure with a subsequent detrimental effect on their performance. As girls are thought to be more affected by a fear of failure than boys this detrimental effect of drill and rote teaching suggests that the methods are particularly unsuitable for girls. Rogers believes that acquiring knowledge solely by means of drill and rote learning is wasteful as the knowledge eventually becomes out-dated. But processes such as those employed in discovery learning are important since they enable a person to adapt to change. Thus he advocates teaching strategies which encourage exploring and questioning.

Accepting the above arguments leads to the conclusion that discovery learning with support and guidance from the teacher is, for girls, a more suitable teaching method than drill or rote for promoting cognitive development in mathematics. As stated above, Rogers believes that learning processes is more important than learning facts. However the evaluation of the effectiveness of different teaching methods for achieving the learning of 'processes' presents difficulties. Knowledge of facts can easily be tested by use of objective tests, but testing processes is more complex and difficult. One method used to identify failure to learn processes has been to look at the errors children make, and this has given rise to further issues related to gender differences in mathematical performance. The following section therefore deals in detail with research on analysis of errors in mathematics assessments.

4.4 Error Investigation as an Aid to Recognition of Underachievement.

4.41 TYPES OF ERRORS

Kent (1981) has suggested that mistakes are a source of learning about thought processes. He identifies two types of mistakes which he classifies either as blunders or as conceptual errors. Blunders often occur, the personality of the pupil being thought to affect *their* frequency (e.g. racing through the questions leads to many blunders). As girls are reported to be more meticulous than boys in their work, one would expect that blunders would be more common in boys than in girls. Blunders are usually irregular and accidental and have no bearing on the learning of future concepts. Conceptual errors are more serious as future learning depends on successful previous learning. Sometimes in conceptual errors, a child may substitute their own concept if they have failed to grasp the correct one and this incorrect concept can act as a barrier to progress. If a girl, who is reported to be quieter and less likely to approach the teacher for help, has an incorrect mathematical concept, then her progress may be affected more than a boy's progress who interacts more frequently with the teacher and is therefore likely to have his errors noticed and corrected.

Many studies have reported cases of children using their own strategies for solving problems and performing calculations (Plunkett,1979; Jones,1975; McIntosh,1978). Taba and Elzey (1964) relates an event where a child described her method of working out an arithmetic question having formed her own incorrect method ... ' *if there are only two numbers I subtract, if there are lots I add* ' This method of thinking would impede further progress in mathematical development. Using case studies Kent (1981) investigated successful pupils' understanding and found that wrong methods had often been used even when their answers were correct. Errors might not result only because of pupil behaviour. Evidence on this point was reported by Kent (1981) who found that teachers sometimes helped to create these misunderstandings. For example 'take away' is taken by pupils to mean 'always getting smaller' and such misunderstanding may cause confusion later at the secondary phase when pupils are presented with, say, a mathematical sum such as (8 - (- 17)).

Teachers rarely have time to diagnose every mistake of the child but they do notice common errors and in particular wrong answers which are made by large numbers of children (Booth,1981). It may be useful therefore to see how the teaching situation contributes to the occurrence of particular conceptual errors and whether certain errors are characteristic of girls or of boys. Examining item clusters for characteristic errors and omissions as well as success rates makes it possible to see where understanding is lacking, and where a particular mathematics topic causes more difficulty to girls than to boys.

One study at Chelsea College, The Strategies and Errors in Secondary Mathematics Project (SESM), investigated particular mathematics errors identified by an earlier project CSMS (Booth,1981). The study looked at errors made by a large number of the children who were then interviewed to discover the precise reasons why these mistakes were made. It was found that some errors were due to children adopting their own strategies while other errors were due to confusion over the conventions of recording algebra e.g. e+2, e2 etc. Gender differences were not reported in the Chelsea study.

A child whose aim is to please the teacher will be susceptible to 'fear of failure' (Dweck and Bush,1976) and thus the child will often turn to peers for help (i.e. to copy and learn nothing or to copy and form their own methods to get from the question to the answer). This practice can lead to the development of errors. Dweck has suggested that it is girls who experience this fear more often than boys and hence are more prone to conceptual errors. Cox (1975) concluded from her research that not only did children make systematic errors but without instructional intervention would continue in the same error pattern for long periods of time. It will be shown later in the review that girls tend to get less attention from the teacher than boys. Once, therefore, girls have established conceptual errors, their progress may be impeded for a considerable time.

Thus there appears to be two important aspects to conceptual errors. First, the kind of errors that occur and the reasons for their occurrence (i.e. their aetiology and developmental psychological aspects). Various studiės have concentrated on this area e.g. Donaldson,1978; Hart,1981; Hughes,1979. The second aspect to the analysis of errors deals with how the teacher detects the occurrence of conceptual errors, how she/he deals with them, and also why some errors escape the teachers notice or even if noticed continue to be repeated by pupils in subsequent years. This second aspect has largely been ignored by researchers. Research relating to the first aspect, of the kind of errors that occur, is presented in the following section.

4.42 ANALYSING ERRORS

In research carried out in Sydney, Australia, the Mount Druitt Longitudinal Study (Houghton and Low,1982) tested 692 children in 'year 4' classes and looked for a developmental factor in children's errors by classifying the types of errors found (e.g. incorrect use of place value, and inaccurate computing). The researchers however didn't interview the pupils so that the classifications were based on written inference rather than on reported evidence. In an earlier study by Brueckner (1930) an attempt was made to identify types of errors made in computation tasks. Brueckner stressed the importance of analysing written work but also emphasised the need to suoplement such activity with interviews. In 1938 he tabulated 8785 errors on decimal calculations into 114 different classifications. Roberts (1968) limited his investigation to computation and identified four error categories - wrong choice of operation, obvious computational error, defective algorithm (correct operation but non-computational error), and random response (no discernible link to the problem). The first and third error type were those most frequently found in low achievers, while for all achievement groups, the most common errors were of the third type (i.e. a defective algorithm). However, no evidence was presented regarding gender differences with these different types of errors. Since girls, generally, are low achievers in mathematics, then girls may make more errors involving 'choice of operation' and 'defective algorithm'. Further research is needed in this area.

4.43 AETIOLOGY OF ERRORS

Watson (1980) has investigated the cause of errors and listed reading ability, comprehension, transformation (i.e. whether the pupil can select the appropriate mathematical processes), process skills (performing the operations), encoding (putting the answer in an acceptable form), motivation, carelessness, and ambiguity of the question as the main determinants. With low achievers of 11 - 13 year olds, 47% of errors occurred in the first three stages of solving the problem (i.e. before the process skills were needed). With younger children, more errors are related to difficulty with reading and comprehension. Since girls' show earlier development of reading skills than boys one would expect them to have superior mathematics performance at this age and the evidence, previously presented, supports this inference.

Other studies have found that many students have difficulty in recognising the correct operation to use for solving a problem and Rees (1973) showed that even students who were competent in computational skills had difficulty in identifying the appropriate calculation in wordy problems. Hart (1980) observed children in problem-solving situations and found that the most important determinant of the difficulty of a problem was the number of items of information which had to be held in the memory and then co-ordinated. Hart's findings receive some support from Kent (1981) who believes that the incidence of an error varies according to the complexity of the item and the context in which it is set. Yet again, figures for gender differences in respect of these difficulties were not documented.

4.44 SUMMARY

Thus the tendency of a pupil to make an error may not be noticed in the classroom unless it is an error made by many pupils, or by a pupil who has a great deal of interaction with the teacher (mainly boys). Two main types of error occur - blunders and conceptual errors - and conceptual errors can be classified into many sub-categories. None of the studies mentioned looked at sex differences in relation to the types of error which occurred. From the literature so far reviewed one might expect girls to make more conceptual errors and boys computational blunders but the evidence on this issue has, so far, not been reported by researchers. As computational blunders don't impede progress in mathematical development, unlike conceptual errors, then the factors which cause teachers not to notice or deal with girls' conceptual errors may have a cumulative effect in impeding girls progress in mathematical development.

As mentiored above, pupils had problems with wordy problems, yet as girls' language development is reported to be in advance of boys' one would expect girls to be more successful than boys in solving wordy problems. The importance of gender differences in language for mathematical performance and development is discussed in the following section.

4.5 Language as an Influencing Factor on Achievement in Mathematics.

Development of language skills has been documented as occurring earlier in girls than in boys. This difference in development may have a differential influence on the way girls and boys approach mathematics and be responsible for girls' difficulties in mathematics. The importance of language as a factor related to mathematics achievement of all children has been demonstrated by a study from the APU (APU,1982) which found, for example, that pupils preferred phrases such as 'reflection in the mirror' to the term, 'symmetry'. The APU first primary survey (APU,1980) also reported that verbal forms were preferred to symbols in multiplying and dividing fractions but worsened performance in problems of the kind, 'what is the sum of' or 'what is 5 times as big as 2 ...'. These preferences could arise because of familiarity, or lack of it, with symbols or words, or alternately could be due to the amount of information which the pupil has to discard in order to find the relevant information.

Nesher (1976) investigated solution of word problems with regard to context, superfluous information, number of steps, and verbal cues. The results suggested that the presence of an extra step necessary for the solution of the problem added to the difficulty as did the presence of superfluous information. Caldwell and Goldin (1979) compared performance on abstract problems with performance on concrete problems and found that concrete problems were considered easier than abstract by primary children. It is likely however that the children would have had more concrete experiences and therefore be unfamiliar with the abstract type of problem. Some young children however were quite able to solve a substantial number of abstract questions. It is clear that the content of a mathematical task is a vital factor affecting the ease with which children can solve a problem. It might be expected that girls would be superior on wordy problems, because of their early language development, and to perform better on concrete rather than abstract problems, because of their late development in spatial skills.

Pupils' agility in their use of language has been recognised as an important factor in classroom learning generally (Bernstein,1971) and in particular for mathematics learning. This need for agility is highlighted by the use of mathematics schemes with young children which can compound the language problem by presenting different styles of writing. As the language used in mathematics is not always part of the child's normal vocabulary, the child's interpretation of the language may not be the interpretation which the teacher had intended (Hart,1981).

Thus the different development rates of language skills in girls and boys would be expected to affect performance on wordy problems. Because of girls' early skills in language one would expect girls to be superior to boys in word problems and this might in fact be the reason why at primary school some studies have shown girls to make more mathematical progress.

As language plays a very important part in early schooling, and as girls develop in language skills earlier than boys, then a teacher is likely to have to spend more time with boys than with girls in explaining a task or a worksheet. Using a mathematics work sheet is likely to lead to the teacher being in closer proximity to the boys more frequently than to the girls. The boys would therefore be able to ask about the mathematics elements of the workcard without having to overtly approach the teacher in the sight of the rest of the class. The result could be that boys are more readily at ease when asking for help from the teacher.

Recent trends in educational psychology stress the importance of training teachers to praise good work, however little there is of it, in order to encourage slow learners and to improve their progress. This emphasis on the slow learner may have led teachers initially to praise boys, given that language is the most prominent focus in the infant class, rather than girl pupils who have less difficulty initially with learning. This would result in boys having a false sense of high self-concept - 'the teacher says I did good work so I must be good' - and leave the girls with a poor self-image - 'Boys must be better than me because they get praised by the teacher for their work and I don't'. This suggests then, that one area of investigation for the present study must be the effect of pupil and teacher behaviour and interactions on pupil learning which works to the detriment of girls in mathematics, yet does not have the same disastrous effect in other curriculum areas. The behaviour of pupils and the teacher within the classroom will be considered in detail in the following section.

4.6 Gender Differences in Pupil Behaviour in the Classroom.

Each pupil has his/her own characteristics and ways of working in a learning situation, and these learning styles may have some influence on gender differences in performance across the curriculum. Judith Whyte reported that boys' learning style is active, participatory, demanding, confident, and independent compared to the girls' style which is more passive, lesser participatory, less demanding on teacher's time and attention leading to a lack of confidence (Whyte, 1983). Whyte went further to say that boys seek attention through misbehaviour while girls seek approval through conforming while reacting negatively to perceived failure. These reports are not contrary to the argument advanced above that boys develop a demanding and confident style following initial extra attention from the teacher.

Various researchers have attempted to answer the question of what exactly determines the style and behaviour of pupils and this has led to a lively debate on the subject. For example Nash (1973) suggested that the pupil's behaviour, both in primary and after transfer to secondary schools, was affected by the way the primary classroom was organised and controlled. As stated above, primary schools give priority to the teaching of reading and language and this emphasis helps to increase the level of achievement of boys who generally have difficulties in these areas. In contrast for girls, there is not a corresponding emphasis on visuo-spatial skills which, it has been shown to cause difficulty for girls. It may be that because the problems of girls' achievement in visuo-spatial skills do not appear until the secondary age they are ignored by the primary teacher. But the effect of emphasising language skills rather than visual-spatial skills begins in the infants and is likely to have a cumulative effect throughout the school years, thereby contributing to the underachievement of girls in mathematics.

The time a teacher spends with boys as compared to girls may also be different at the secondary age level. Nash (1973) studied mathematics lessons in a secondary school and found that 42% of the mathematics lesson was spent on written, seated work, and only 13% on oral work which leaves the teacher monitoring or dealing with individuals for most of the time. Given that Adams and Biddle (1970) found pupils stop working when the teacher leaves the group, it seems likely that pupils' behaviour is largely determined by the behaviour of the teacher. When the teacher is close to the pupil, the pupil will watch, but when the teacher is elsewhere the pupil will wait and become disengaged from the task. This suggests that the great amount of time spent on written work could lead to pupils becoming disengaged for some considerable time. As boys are known to misbehave in ways which attract the teacher's attention more than girls they will achieve more contact with the teacher for discipline reasons and this physical presence of the teacher will lead to boys doing more work. Girls, being more passive, according to Whyte (1983), will do less work but also get less teacher attention. The question remains, however, that if attention to boys is due to misbehaviour, why the effect on learning is limited to mathematics and not other curriculum areas. It is unlikely that boys misbehave only during a mathematics lesson. A more detailed examination of classroom behaviour is necessary to answer questions of this kind and in this country a major research of primary practice has been carried out at the University of Leicester. The following section describes the behaviour of pupils as observed over a period of up to 3 years in this ORACLE study (Galton et al,1980).

4.61 THE ORACLE STUDY OF PUPIL TYPES - THE PRIMARY STUDY

The ORACLE study of the primary classroom (Galton et al,1980) found that over the whole curriculum, pupils spent, on average, 58% of their time totally on-task, mostly on their own with a small amount of time listening to the teacher. The study however, did not attempt a breakdown of this 'time on task' across the different curriculum areas such as mathematics, language, and art. It is possible therefore that on-task time was greater in some curriculum areas than others. The ORACLE study provided a comprehensive study of pupil behaviour in the classroom and greater attention will be paid to its findings because of the relevance of the ORACLE research to the present study.

The ORACLE team set out to identify the effectiveness of different teaching styles for different types of pupil. A statistical method, cluster analysis, was used for the identification of pupil groups having different behavioural characteristics. The data was provided by an observational record (Boydell,1974,1975) concerning a target pupil's activity, work base, mobility, and interaction both with the teacher and other pupils. Analysis of data from the primary schools resulted in four pupil types;

> 1) Attention Seekers who worked on task for two-thirds of the time but tended to seek out the teacher's attention more than the other groups did, and spent a large amount of time waiting at the teacher's desk or moving around. The subsequent interaction with the teacher was usually task-related (e.g. 'shall I do number two now?') and this suggests that these pupils demanded constant feedback. There was a sub-group of these pupils called Attention Getters, the interaction usually being initiated by the teacher rather than the pupil, but as the pupils' non-verbal behaviour (e.g. disruptive behaviour) initiated the interaction they were still called Attention Seekers. There were few Attention Seekers in classes which were noted for greater amounts of group work, but more Attention Seekers than expected in classes with teachers who used more than one method of teaching and who tended to make an immediate response to the demands or needs of the children.

This leaves open the question of why there is then still a need for the pupil to continue to be an Attention Seeker? The ORACLE evidence is that teachers change their style as a coping strategy. Attention Seekers get a tolerant hearing from the teacher, but if there are several Attention Getters in the class the teacher changes style (e.g. to whole class teaching) so that all the children can be controlled and 'attention getting' is minimized. However, evidence is that where the teacher reverts back to other forms of organisation these children go back to being Attention Getters.

> 2) Intermittent Workers were pupils who spent most of their time in base and avoided the teacher's attention. They spent more than an average amount of time watching the teacher and

other pupils. Intermittent Workers' verbal interaction was limited to conversation mainly about non-task subjects and with same sex peers from their own base. Despite the attention to the teacher and other pupils, Intermittent Workers still managed to spend two-thirds of their time on task. These Intermittent Workers were over-represented in classes of teachers who used individual work and of those teachers who changed their style of teaching regularly where it was easy for a pupil to go unnoticed for a long time. In classrooms where teachers spent a relatively great amount of time addressing or monitoring the whole class there were few Intermittent Workers.

3) Solitary Workers were pupils who had little interaction with anyone. They spent a high amount of time (75% of their time) on task and in their own work base. Most interactions with the teacher were as a member of the whole class getting feedback from listening to the teacher and this left the pupils as rather solitary. Most of these pupils were in classes of teachers who favoured class teaching and were therefore suited to the teaching style of bouts of instruction followed by periods of individual work.

4) Quiet Collaborators were few in the study but were similar to Solitary Workers in that they worked as high and had low verbal contact, but the teacher spent more of her/his time with them mainly in a group or class setting and told them things rather than encouraged discussion. They spent more time on routine than the other groups. Few Quiet Collaborators were found in classes where teachers set individual tasks or in class teachers, but many were found with teachers who favoured group work.

In the second year of observation, some of the ORACLE children kept their 'type' even when their teacher 'style' changed. These were the Solitary Workers and the Quiet Collaborators. Attention Seekers and Intermittent Workers were more likely to change type, even if the style of the new teacher remained the same. The Oracle researchers commented that '*it is now clear that in spite of the strong influence of teaching style upon pupil type, other factors must also be at work. If it was a* *clear case of cause and effect then one would expect all pupils to change, but they don't '* (Galton and Willcocks,1983,page 38).

Some pupils changed the cluster type to which they belonged even when their teachers didn't change style and therefore pupil types don't appear to strongly affect teacher style. Although the ORACLE research team reported that four pupil types resulted from the analysis of the data, the study on the primary data did not report whether any 'type' was associated with a particular sex of pupil, or with any specific curriculum area. However, such information is available for the study of pupils after transfer to the secondary schools (Galton and Willcocks,1983) and details of the transfer study will be presented in the following section.

4.62 THE ORACLE STUDY OF PUPIL TYPES - THE TRANSFER PUPILS

The ORACLE research team studied 103 first year pupils and 28 teachers in six middle or secondary schools. Three local authorities were involved, each with a different age of transfer. The schools in each authority were paired to obtain a contrast in style. One school took a primary approach to first years, the other adopted a secondary style with a different teacher for each subject. As with the primary study, four cluster types resulted from the analysis but differences in the characteristics of the pupils compared to the primary study led to new pupil type labels. The pupil types were described as:

> 1) Easy Riders who did enough to avoid the teacher's attention, were non-involved and distracted for a relatively large amount of time. More than 80% of pupils were Easy Riders in mathematics lessons and 50% in English and in science.

2) Hard Grinders who stayed in their base and had little interaction with pupils or the teacher except as part of the whole class. Only 6% of pupils were Hard Grinders in mathematics, 35% in English and 40% in Science.

3) Toilers who were few in the study, only 10% of the pupils in mathematics being hard working Toilers. These pupils were characterised by the amount of group work they did compared to the other types.

4) Fusspots were few in number too. These pupils appeared to be helpful to others, doing other pupils' work for them.

In this study of secondary pupils, children worked either in single-sex pairs or individually. Pupil-pupil interaction consisted mainly of gentle whispering with the immediate neighbour. It was the lack of teacher-pupil interaction which characterised the transfer mathematics lessons from the primary ones, although the primary data was aggregated over the whole curriculum. Thus after transfer pupils tended to behave and interact in different ways according to the curriculum area involved. ORACLE showed that, in general, teacher style determines pupil behaviour. The data suggested that where a teacher is observed in more than one year a teaching style remained unchanged whereas a high proportion of pupils changed their type from one year to the next. It remains to be seen, however, whether boys adopted a different 'pupil type' than girls in each curriculum area.

In the ORACLE transfer study, more boys were Easy Riders than Toilers in English lessons, in science more boys were Toilers than Easy Riders while for mathematics no gender differences in the presence of a particular pupil type appeared. For girls the reverse was true. However, because of the considerable overlap of boys and girls in each pupil type, these findings cannot be interpreted solely in terms of gender differences. The ORACLE report likened Group Toilers to Quiet Collaborators, Fusspots to Attention Seekers, and Hard Grinders to Solitary Workers but argued that there were too many divergencies for each group to be equated with each other. The primary results were based on the whole curriculum whereas secondary results were based on separate areas. Further analysis of the primary data is therefore necessary to compare the data with that of the transfer study over different curriculum areas. The results of the analysis will be presented in Chapter 7.

4.63 THE RELATIONSHIP BETWEEN PUPIL BEHAVIOUR AND ACHIEVEMENT IN THE ORACLE STUDY

One important question, left unanswered so far, relates to the influence of 'pupil types' on achievement. The relationship between pupil type and pupil achievement was also investigated by the ORACLE team (Galton and Willcocks, 1983) who used three Richmond tests of basic skills in mathematics, language, and reading comprehension (France and Fraser, 1975). The highest scores in the primary phase, in descending order, were obtained first by Solitary Workers, then by Intermittent Workers, followed by Quiet Collaborators, and lastly by Attention Seekers. When residual scores were used as a measure of progress there was only one significant result and that was in language skills with Solitary Workers doing better. When co-variance analysis was employed to control for teaching style, the differences were no longer significant. Pupil type therefore appeared to make little difference to pupil progress once the effect of teacher style was taken into account.

ORACLE also found that after transfer although most children had made good progress on basic tests of mathematics, reading and English in their last two years in the primary school, a year after transfer only 63% had made gains on the same tests, and these gains were smaller than throughout the primary years. Just under one-third of pupils in the study regressed on their test results. Girls, however, did better than boys with 75% making progress and 15% falling further behind. This compares with less than 50% of boys making gains in progress and 45% who did less well than in their final primary year. The reason why a greater number of girls make progress after transfer might be that girls adjust more quickly than boys to the secondary school. Whatever the reason, the greater progress of girls after transfer should lead one to expect that girls would achieve at least the same performance levels as boys in later school life. The evidence, as we have seen however, is that they don't.

ORACLE also found that mathematics teachers tended to teach on a one-to-one basis, while English and science teachers used more whole class teaching, with English teachers encouraging co-operative work between pupils. These different organisational methods of teaching led to different behaviour among pupils; in mathematics most pupils became Easy-Riders, doing just enough to avoid the teacher's attention. The few who worked hard in mathematics worked hard most of the time. In science and English nearly half the children worked hard but the workers in English were not always the workers in science. This suggests that different methods of teaching may be one factor which contributes to the differential performance of girls and boys in mathematics as well as in English.

To summarise, the ORACLE analysis of pupil behaviour in the primary school has led to the recognition that four 'pupil types' exist, each type being more prevalent in classes with certain teacher styles than in others. *Information* relating to curriculum areas in the primary school was undocumented in the ORACLE study and would be useful for a comparison with the results of the analysis of data from observations in secondary schools. Results of this further analysis on the ORACLE data are presented in Chapter 7 of the present study. The ORACLE analysis of pupil behaviour in the secondary schools gave rise to four pupil types similar in many ways to the primary pupil types. At the secondary level pupil type appeared to be related to the curriculum area involved. Some gender differences were found with respect to the 'pupil type' within each curriculum area. There was some evidence that teacher style in the secondary school played a part in determining the pupil behaviour in different curriculum areas and therefore the nature of the relationship between methods of teaching and gender differences in mathematics achievement emerges as an important issue which is germaine to this present study. There is evidence of an effect of a teacher's attitude, philosophy, belief, etc. on his/her teaching style. Also the ORACLE evidence suggests that teaching style affects pupil achievement which in turn affects pupil attitudes. Therefore the possibility exists of indirect links between attitudes of the teacher and those of the pupil with teaching style. Pupil achievement is an intermediate variable in this process. The following section therefore examines the research literature on teacher attitude in relation to the teaching and learning of mathematics.

4.7 Teacher Attitudes and their Effect on Achievement of boys and girls in Mathematics.

According to Newbold (1977) the mathematical experience of a child at primary school plays a part in determining the attitude and achievement at secondary school level which in turn affects the pupil's choice of subject in later school years (i.e. prevents the majority of girls from choosing to study mathematics at a high level). Newbold has listed three factors involving teachers which he suggests are of importance to the mathematical experience of a child. These are 1) the teachers' attitudes and their effect upon the children, 2) the teacher expectations, and 3) the effects of the teacher's perceptions of girls' performance in mathematics.

Seemingly insignificant acts by a teacher appear to have great influence on a child's behaviour and attitudes (Roberts,1971). At the same time however, the teacher is thought to be constrained by the pupil's expectations, abilities, attitudes and language (Blyth,1965; Hargreaves,1972; Nash,1974). Good and Brophy (1978) have suggested that teachers' behaviour and personality act as a model for pupils and a teacher's lack of confidence in mathematics will show in his/her behaviour. A display of a lack of confidence by the teacher would subsequently be transmitted to the pupils, affecting in turn, their attitudes to the subject. Bearing in mind that most primary teachers are female and who are likely to act as a model to girls rather than to boys, then any expression of a lack of confidence would be transmitted more readily to girls rather than to boys.

Rogers (1969) believes that a teacher's positive attitude towards a pupil and a good relationship between the teacher and pupil are essential if achievement in mathematics is to reach a high level. Furthermore, factors such as boredom, anger, sympathy, acceptance and trust in a pupil's qualities, and any empathetic understanding which a teacher may express will all affect such a relationship. The teacher's perception of the child has repercussions for what goes on in the classroom. The pupil-teacher relationship can determine the achievement grouping in which the child is placed, the type of teaching the child receives in terms of both close supervision and of interaction with the teacher and can ultimately affect the pupil's self-concept of his/her ability in mathematics (DES,1978). If the relationship between the teacher and a pupil and the teacher's perceived concept of the pupil is biased in favour of boys, then a teacher's attitude is a factor which is likely to affect the achievement of girls in mathematics.

The factors which determine the teacher's perception have been the subject of a number of research studies. As an example, a Scottish study of 16 schools found that a teacher's perception of a child's ability not only relied on objective measures but on other subjective characteristics of the pupils as well (Morrison, McIntyre and Sutherland,1965). Thus a teacher's attitude towards both mathematics and the pupils' behaviour are likely to have a different effect on boys compared to girls particularly during the primary years.

4.71 TEACHER CONFIDENCE

Evidence for teachers' lack of confidence in mathematics is provided by a questionnaire study on attitudes towards mathematics which was devised by a group of teachers in Derby (Sturgess,1980). Forty primary and twenty-five secondary teachers took part in the study. Most of the teachers expressed a liking for mathematics but a lack of confidence in teaching certain topics within mathematics. A desire for traditional method and content was expressed, partly because they could relate this to their own learning experience. Although the questionnaire did not probe deeply into the questions of liking and confidence, the teachers reported agreement with Nash (1974) that the attitudes of teachers are important factors in relation to pupils' mathematical achievement, particularly in the way these attitudes are communicated to some pupils through classroom behaviour and interaction. The Derby study reported some differences between primary and secondary teachers and those differences related to teacher confidence. Primary teachers who reported to dislike mathematics themselves, at the same time however, reported to like teaching mathematics even though they still felt unsure and had a lack of confidence. Secondary teachers reported that they had always liked mathematics and had little if any anxiety over teaching it. It could be then, that primary teachers who are mainly female unwittingly pass on to their pupils this feeling of fear or dislike of mathematics. With the teacher acting as a model, these feelings may be passed on to girls more strongly than to boys. Thus feelings of fear and dislike could be established prior to entering the secondary school.

That teachers' lack confidence in teaching mathematics has also been found by a number of other researchers (e.g. Ward,1979; Ray,1975; King,1978; Straker,1978). Walkerdine and Walden (1982) for example found that teachers blamed their own faulty teaching for poor mathematical achievement of pupils. Lack of confidence may limit the extent to which primary teachers teach mathematics and thus lead to an emphasis on computational skills and rule following rather than on understanding. Girls, seeking to please the teacher, will concentrate on these skills. This would be one explanation for gender differences in achievement in different topics within mathematics and demonstrates the possible interactive effect between teacher confidence and gender in relation to mathematics achievement. As mathematics becomes more analytical, at the secondary age, so girls might be expected to have increasing difficulty in achieving high scores on mathematics assessments.

Edith Biggs (1983) has attempted to investigate teachers' attitudes to mathematics by using interviews and questionnaires but the teachers' responses to the questionnaires were so different to their responses in the interviews that the study was abandoned. It appeared that questionnaires were answered according to what the teachers felt it was desirable to say rather than what they actually thought and this demonstrates the need for questionnaire studies to be supported by other research techniques.

Teachers' attitudes towards mathematics have also been researched at the teacher-training stage. Ray (1975) found that main mathematics students in a teacher training college, not surprisingly, reported a positive attitude towards mathematics, but had a negative attitude towards the teaching methods they experienced prior to college. It appears, therefore that adverse attitudes towards the teaching method used in mathematics certainly didn't deter these mathematically inclined students from studying mathematics to a higher level. The same, however, may not be true of less able students.

Related to attitude is personality and various studies have suggested that teacher personality is related to the learning climate in the classroom (Amidon and Flanders,1961; Cogan,1954, Walberg,1969). This issue will be discussed in the next section.

4.72 TEACHER PERSONALITY

Ryans (1960) used a method of systematic observation supported by a questionnaire study to investigate teacher personality in relation to classroom behaviour. The study involved 837 primary teachers and 910 secondary teachers and the results suggested that male and female teachers, by way of different personalities associated with their gender, have different effects on achievement according to the subject matter being taught. Other studies support this suggestion that the teacher's gender has an effect in some way on pupil's achievement. For example, Douglas (1964) reported that girls do best in subjects which are usually taught by women, and boys in those taught by men. However, a study by Anderson et al (1971) and another study by Olson (1971) found that teacher gender was not a good predictor of the quality of the teaching in any classroom.

A study of first graders in mathematics used 2-way analysis of co-variance on pre-test and post-test mean gain scores of a mathematics test and the results showed that students taught by males were superior in performance than those taught by females (Barnett,1980). These findings have been supported by Vairo (1969) who believes that male teachers can convey to pupils an attitude that mathematics is a worthwhile subject. Some support also comes from Scheiner (1972) who found that first grade pupils of male teachers display more positive attitudes towards school, teachers, peers, learning and self. The ORACLE study, however found no sex differences in achievement related to teacher sex (Galton,Simon and Croll,1980).

These conflicting results suggest that there may be several factors relating to the teacher's attitude which have an effect on pupil achievement. Each of the above studies investigate only some of the factors. Begle (1979) found seven variables relating to teacher attitude which had a positive effect on pupil achievement in mathematics. These were 1) whether teachers emphasised teaching for understanding or rote learning, 2) concern for pupils, 3) involvement in teaching, 4) non-authoritarian orientation, 5) like versus dislike of mathematics, 6) creative versus rote view of mathematics, and 7) pupils' need for approval. Although positive aspects of 1 and 6 led to greater achievement by pupils, less concern for pupils rather than more led to greater achievement. It could be that more concern expressed by the teacher, perhaps to girls, the greater the loss of confidence by the pupil. The results of the studies reviewed here suggest that the evidence to support the effect of teacher gender and attitude on mathematical performance of girls is inconclusive.

The conflicting results on the effect of teacher gender on pupil performance may be due to the contribution of other teacher characteristics towards the establishment of teachers' attitudes and the subsequent effect on pupil achievement in the classroom. To investigate this possibility, teacher attitude and related characteristics will be studied in further detail.

4.73 TEACHER QUALIFICATIONS

Earlier in this study it was suggested that primary teachers, who are mostly female, act as models and transmit to girls a lack of confidence in their mathematics performance. There still remains unanswered, however, the question of why primary teachers lack this confidence.

One obvious explanation is that lack of confidence in teaching mathematics is linked to the level of mathematical qualifications of the teacher. In a study of 40 schools by Ward (1979), less than 60% of primary teachers had an 'O' level and less than 5% had an 'A' level in mathematics. Primary teachers, with low levels of achievement in mathematics may therefore teach in a narrow manner using published schemes and fail to provide concrete experiences which, as discussed earlier in the present study, are particularly essential for girls' mathematical development.

The Cockcroft Committee's survey of teachers (Cockcroft, 1982) by implication placed the emphasis on the importance of academic qualifications by rating teachers on one of four categories - good, acceptable, weak and nil. However, no attempt was made to correlate these qualification ratings with teachers' classroom performance in terms of pupil' progress in mathematics. It is, therefore, only conjecture that the weaker a teachers' qualifications in mathematics the poorer their performance in the classroom. It may be that the manner in which teacher attitudes affect pupil performance in the classroom is completely divorced from the issue of teacher qualifications.

If primary teachers who, as has been said, are mostly female, have a low self-concept of their own ability in mathematics, they may be the victims of the self-fulfilling prophecy and expect themselves to be poor at teaching mathematics. Evidence cited earlier in the present study suggests, however, that this is not the case. Another alternative explanation is, of course, that a teacher, whose own experience as a pupil was of girls generally being low achievers at mathematics, will expect girls they presently teach to be poor at mathematics too and treat them accordingly.

There is evidence for teacher expectation and attitudes affecting pupils' performance in mathematics. While some of it is ambivalent, the effects are generally held to operate to some extent, although the exact nature of the effects are unclear. Research seems to conclude that teachers convey suggestion of performance levels to pupils and the pupils behave accordingly, thus reinforcing teachers' views and hence behaviour towards pupils of different achievement levels.

There are four critical areas of teacher behaviour on which research evidence has focussed a) Assessment of pupils' performance b) Questioning of pupils, c) Praise and criticism, and d) Pupil behaviour and contact with the teacher. The following sections review the evidence in each of these critical areas.

4.74 ASSESSMENT OF PUPIL PERFORMANCE IN MATHEMATICS

A report by Ernest (1974) stated that both male and female teachers regard boys as superior to girls in mathematics achievement. It is possible that the teacher holding this view will teach and behave accordingly, and that boys and girls will take on the role which reflects the teacher's behaviour and attitudes. This poses the question as to whether teachers actually do teach and behave differently towards high achievers compared to low achievers. Weiner (1978) cited the Rosenthal and Jacobson (1968) study of the 'Pygmalian in the Classroom' effect as evidence for teachers' discrimination against pupils considered to be low achievers. In the Pygmalian study attempts were made to manipulate teacher expectation by attributing false IQs to certain pupils' records. The progress in achievement made by the pupils seemed to correlate with the false IQs which had been communicated to the teacher. The study has been widely criticised for the experimental procedures used (e.g. Thorndike, 1968; Snow, 1969). Brophy and Good (1970) however, have suggested that the credibility of the source of information about IQ levels was responsible for the results of high IQ rated pupils exhibiting superior performance. A teacher will respect the judgement of another colleague and the pupils will, in turn, respect the judgement of the teacher. Teachers often participate in this kind of assessment by the passing on of reports and school records to subsequent teachers. Weiner concluded that teachers' expectation does have effect in the classroom.

If teachers do regard boys as better than girls in mathematics performance, boys may come to regard themselves as superior and perform in the manner expected. Selkirk (1974) added the idea that pupils have a mathematical 'ceiling' beyond which they cannot go. It may be that teachers' perceptions set the 'ceiling' for the pupils, with a lower ceiling for girls so that they perform according to the teacher's expectation.

This poses a question of the criteria used to arrive at the decision that boys are superior to girls in mathematics. Some researchers, e.g. Morrison, McIntyre and Sutherland (1965) have reported that teachers evaluate girls' attainment by non-objective measures such as good behaviour and sociability, and Walden and Walkerdine (1985) suggested that the modern emphasis on method rather than correct answer in mathematics has led teachers to evaluate pupils' mathematical achievement based on activity, flair, divergence and confidence, which are qualities attributed in the main to boys.

The effect of pupils' various qualities in influencing teacher perception of mathematical achievement is not a simple one, as evidenced by Nash (1973) who found a correlation between the teacher's perception of a child's social class with the child's general academic performance, whereas actual social class did not. Thus research has produced evidence of correlations between perceived social class and general achievement, and also correlations between qualities attributed to boys in mathematical performance and general achievement. The question remains unanswered as to the extent of the interaction between perceptions of social class and qualities associated with mathematical performance.

The argument that boys' performance in mathematics is superior to girls' because of teachers' perceptions relies on evidence of differential treatment of the sexes and behaviour of the pupils. One area of research on differential treatment relates to the type of questioning which boys and girls encounter in the classroom learning environment. The following section investigates this evidence.

4.75 QUESTIONING OF PUPILS

Differential treatment of pupils by teachers has been investigated by several researchers. In one study, Budd Rowe (1974) found that low-achieving children were given less time to answer a question than those of higher achievement levels. When teachers gave more time, deliberately, low achievers answered more questions than they had done previously. Another study, Galton and Delafield (1981) found in primary schools that it was the least able children who were most affected by teacher expectations. When low-achievers made a response they were less likely to receive a follow-up comment from the teacher whereas high achievers received immediate feedback. These findings support Budd Rowe's view (1974) that the manner in which teachers converse with their pupils is largely dependent upon ,their initial concept of the child's ability. These results have implications for gender differences in mathematics. If teachers perceive girls as low achievers, then it will be girls who are given less time to answer questions, and who are less likely to receive immediate feedback, and hence girls' progress in development of mathematical concepts will be impeded.

If girls are perceived as low achievers and hence given less time to answer questions, it follows that there would be little opportunity for low achievers to receive praise for correct responses. Research on praise and criticism given to high and low achievers is presented in the following section.

4.76 PRAISE AND CRITICISM

Silberman (1969) identified four attitude groups that teachers might hold towards pupils - attachment, concern, indifference, and rejection -

and asked teachers to place three children into each of these groups. The pupils were then observed during lessons, by means of participant observation, with the focus on interactions conveying praise or criticism. Silberman reported that attachment tended to be exhibited towards high achievers, these pupils being well behaved in the classroom. Pupils shown indifference by the teacher tended to be passive and inconspicuous. Teachers spent a relatively great amount of time with pupils they expressed concern for, but also with those they rejected. This time with the latter groups was mainly devoted to disciplinary interactions. Silberman claimed, that in general pupils labelled as poor received more criticism and less praise than pupils who were perceived as good.

Brophy and Good (1970) recorded dyadic interactions and found that even when low-achieving pupils gave a correct answer they tended to get less praise whereas if they got an answer wrong they came in for a greater amount of criticism. These findings have been confirmed by recent studies (Dusek,1975; Hillman and Davenport,1978). None of these studies tested the children. It could be that teachers asked more difficult questions to brighter pupils and therefore felt more praise was deserved. If slow pupils were asked simple questions and answered incorrectly then maybe they deserved more criticism.

The research described above failed to investigate the incidence of praise/criticism in interactions with girls compared to boys. Thus evidence to support the argument that girls receive less praise for academic work and gain a poor self-concept is not provided by the research cited above.

However, Galton, Simon and Croll (1980) found that a teacher will stop asking questions to a girl who is constantly wrong or too shy and Rowe (1974) found that teachers allow a longer time for answering if they think the child usually gives the right solution. Many studies have reported that boys tend to get more attention and specific criticism from the teacher than girls (Spender,1981; Stanworth,1981; Galton et al,1980; French and French,1984; Clarricotes,1980; Sears and Feldman,1974; Schonborn,1975; Fennema,1979; Scott,1978; Good,Sykes and Brophy,1973; Heller,1978; Becker,1981) but Sears has also reported that when girls are criticised it is for lack of skill whereas boys are criticised for breaking rules. Whether this differential treatment of boys and girls contributes to gender differences in mathematical performance needs further investigation. Good (1970) found a close relationship between the pupil's achievement and the opportunities they were given to take part in classroom activities. But these studies are over general curriculum areas; if broken down by subject then it may be that the differences are greatest for males in mathematics and greatest for girls in English. Leinhardt et al (1979) has supported the above findings for mathematics and also found the reverse to be true in reading and so it could be that some of these factors contribute to the occurrence of gender differences in mathematics achievement. Leinhardt has pointed out that although the differences in teacher behaviour towards the sexes were not very great, it would accumulate over the primary years.

It is possible that the pupil's concept of what goes on in the classroom is different to what is actually observed and this possibility needs further examination as pupil perceptions may affect performance and attitudes in mathematics more than actual classroom factors.

4.77 PUPIL BEHAVIOUR AND CONTACT WITH THE TEACHER

Stanworth (1981) found that even pupils reported that boys were twice as likely to seek teacher attention and were more likely to offer contributions to discussion than girls so it is clear that pupils are aware of these differences and may be affected by them in some way. Fennema (1980) believes this extra attention communicates a feeling that mathematics learning is more important for males than females, particularly as computational skill is rewarded in girls but higher cognitive skills such as problem solving are rewarded in males (Fennema and Sherman, 1977). As the pupil advances in study these higher level skills become increasingly important. Croll and Moses (1985) reported that children who are regarded by the teacher as having learning or behaviour problems (mainly boys) received most of the attention from the teacher. And even of the other children it was boys who received more attention but this was mainly a very few boys getting a lot of attention rather than a situation of most boys getting more attention than girls. Thus the problem becomes one of classroom management of how to deal with problem children, and with pupils who monopolise the teacher's attention.

Although Heller (1978) found that girls received less criticism than boys, there was no significance between boys' achievement and the number of interactions with the teacher. She therefore concluded that the extra attention given to boys cannot be the causal factor for girls' underachievement. It could, however, be the type of such interactions that are important, and study of such interactions would appear to be an essential ingredient of the present study.

4.78 SUMMARY

Three main areas pertaining to teacher attitudes and their effect on mathematics achievement appear to arise from the research reviewed 1) the teacher's own attitude towards mathematics, 2) the teacher's expectations of a pupil's performance, and 3) the teacher's perceptions of performance.

Primary teachers, of whom most are female, admit to a lack of confidence in their own mathematical ability and this attitude may be conveyed to girls more than boys by the teacher acting as a model. Added to this 'modelling' effect, teachers with little confidence in mathematics are thought to teach in a narrow and restricted way which severely limits the opportunity for discussion which has been said to be particularly important for girls' development of mathematical concepts.

A teacher whose childhood experience included classes where girls did less well at mathematics than boys may expect the girls they teach to be inferior too and treat them accordingly. The pupils' behaviour may reflect this judgement leading to a self-fulfilling prophecy whereby girls perform less well than boys at mathematics. This argument would also hold true in reverse for English language in which girls have superior achievement levels to boys.

A teacher uses his/her perceptions of the pupils to determine the grouping, type of teaching and questioning, and the amount of supervision required. Thus a perception of girls as low achievers in mathematics will lead to girls receiving different treatment to boys in the classroom, this treatment being detrimental to the achievement of girls.

Some studies have reported that pupils of male teachers exhibit superior performance in mathematics to pupils of female teachers but the ORACLE study failed to replicate this finding. It was also noticeable that the superior achievement which was reported did not differentiate pupils by gender, and so it seems that teacher gender by itself may not be a major contributory factor in the underachievement of girls.

Four critical areas of teacher behaviour have been reviewed a) assessment of pupils' performance, b) questioning of pupils, c) praise and criticism, and d) pupil behaviour and contact with the teacher.

Evidence was presented that the teachers' treatment discriminates between high and low achievers. However, the argument that teachers view girls generally as inferior to boys relies on evidence which reports that teachers evaluate pupils on non-objective measures. Much of this evidence has been based on conjecture and is therefore, weak.

One way in which teachers discriminate between high and low achievers is in the presentation of questions. Low achievers are given less time to answer, are less likely to get feedback on an answer than high achievers, and get less praise for correct answers. Girls who are shy tend not to be asked questions. Therefore, the reason why girls are not asked so many questions as boys in class discussion may be due more to their shyness than to teachers' perception of them as low achievers.

In mathematics, girls tend to be criticised for lack of skill whereas boys are criticised for breaking rules so the effect of a 'fear of failure' on academic achievement is greater for girls. This effect is compounded as girls are rewarded in computation skills, but boys are rewarded for high cognitive skills such as problem solving. As a result, girls enter secondary school with a low self-esteem regarding their ability to cope with the higher skills of mathematics, such as problem solving; skills which are important at the higher academic level.

Although teachers spend more time with boys than girls, it is partly due to boys seeking attention more forcibly than girls. Teachers thus have the problem of how to deal with pupils who monopolise their time. It is apparent from the research that the amount of attention given by the teacher is not a causal factor for girls' underachievement in mathematics, but the type of interactions which take place may be and further investigation in this area is necessary. Many of the differences reported in the research reviewed are small but they would accumulate over the years and therefore the differences described above cannot be rejected as a possible source of underachievement of girls in mathematics.

For many of the above issues, the question is still unanswered as to why such detrimental effects upon girls' performance should occur only in mathematics and not in English. Lack of confidence is not necessarily the same as shyness, but the latter is a possible reason why girls are reluctant to participate in class discussion. It has been argued that the teacher fails to ask questions to girls because they don't wish to embarrass shy girls, but if this was the case shy girls wouldn't participate in other curriculum areas like English, yet the evidence is that they do. If instead of shyness the girls suffer from a lack of confidence in mathematics, then girls may be reluctant to show a readiness to answer questions and participate in discussion. The lack of confidence would not necessarily apply to other subject areas. An alternative possibility is that class questioning is more common in mathematics than in English and so shy girls would only be affected in mathematics. Further investigation into styles of teaching in different curriculum areas is required to clarify this issue.

Much of the evidence cited above relates to general curriculum areas. At present, there is little evidence pertaining to mathematics alone. Different mathematical tasks demand different kinds of teacher control in the classroom (Bossert,1979) and if teachers view all mathematics as factual, they will teach in a different way to those teachers who regard it as important to develop mathematical concepts. These different ways of teaching may have different effects on the achievement of girls and boys. The argument for the selective use of different teaching styles has a long history. Various reports and studies have noted the need for teachers to be free to discover new ways for teaching that will suit the particular school and situation in which they are working (e.g. Bryce Report,1895) but the question of suitability of a particular approach for particular pupils i.e. girls compared to boys has not been considered separately from pupils as a whole. The effectiveness of teaching style may therefore be a contributory factor to the underachievement of girls in mathematics and is discussed in the following section.

4.8 Teacher Behaviour and the Effect on Achievement in Mathematics

4.81 TEACHING STYLE

To evaluate one teaching method over another it is necessary to have descriptions of the different teaching styles which are in use. One attempt to describe teaching styles, a study by Bennett (1976), used teacher questionnaires to investigate classroom organisation. There were 468 replies from 4th year teachers in primary schools in Lancashire and Cumbria to a questionnaire consisting of 38 items of a YES/NO type; 37 teachers and their pupils were assessed on academic and personality tests at the beginning and end of the academic year. Bennett used the method of cluster analysis to define 12 teacher styles but 5 of these were rejected as being unclearly defined so that 7 styles remained. Bennett found a strong relationship between primary teachers' aims and teaching styles. This study has, however, been criticised both for its design and the terminology used to describe the seven styles (Wragg,1976; McIntosh,1979).

A study in the United States by Solomon and Kendall (1979) used observation of the classroom and cluster analysis in an attempt to define the most distinctive patterns of classroom organisation. Various cluster methods were employed which all produced different results. However, six clusters were found to be consistent and similar in some ways to the styles found by Bennett (1976). The characteristics of these styles were :

1) pupil autonomy and integrated subject matter;

2) moderate discipline and pupil autonomy, with an emphasis on creativity;

3) A mixture of teaching individual, groups and class;

4) Separate subjects taught but with pupil self-direction;

5) class teaching and individual work, with little freedom of movement;

6) Academic, disciplined and formal teaching with the use of assessment rather than punishmnent to manage.

Solomon and Kendall reported that formal and informal labels were too global to describe classroom organisation and a description of the many related factors were more meaningful and this view has been supported by the ORACLE study at Leicester (Galton, Simon and Croll, 1980).

Bennett described the classrooms in his study as 'formal', 'mixed' or 'informal' and argued that formal methods were superior in developing basic skills and that informal classes did not compensate for this by the development of greater creativity. Pupils' motivation, however, was found to be higher in informal classes but it was accompanied by increased anxiety (Bennett,1976). The difference between girls and boys in levels of anxiety, motivation and creativity have been well documented and will be discussed in depth in section 4.9.

Solomon and Kendall's (1979) results support Bennett's findings. They noted that high achievement concurred with high esteem, although whether it was a classroom factor that was the cause of high esteem or the high achievement that was the causal factor cannot be determined from their data. Similarly, it cannot be assumed that a particular style of teaching caused high achievement or creativity. It could equally be the pupil's strengths and weaknesses which determined the style chosen by the teacher. To consider the importance of style of teaching in relation to gender differences in mathematics it is necessary to observe individuals of varying abilities within the same environment to be sure that gender differences observed are not differences caused solely by environmental factors.

As reported earlier in the study, teachers may see mathematics either as factual or as creative. It follows that if the creative approach is taken, the children are likely to be 'active' so that formal discipline would be more difficult to maintain. An informal method of teaching would therefore seem to be the most appropriate (Bossert,1979). Bennett (1976) has acknowledged the advantages of informal teaching for creative areas, particularly the teaching of arithmetic concepts at primary level. But if one style is best suited to the teaching of arithmetic, there is no explanation as to why this one style, when used, should result in better performance by girls in arithmetic at the primary level. There must be factors other than teaching style influencing the achievement of pupils.

Criticism of Bennett's study (1976) together with developments in statistical methods led to a re-analysis of the data (Aitken, Hesketh and

Bennett, 1981). In this re-analysis, when probabilistic clustering was used, a two class model resulted -

1) Teachers who restricted both movement by the children and the width of the task and taught by talking to the whole class or with pupils working individually. The curriculum tended to be taught as separate subjects and timetables were used for organisation,

2) classes where children worked individually or in groups on integrated subjects. The teacher did little marking during class time.

When however, the analysis was extended to a three class model, then there was also

3) classes sharing characteristics of 1 and 2 above but who used textbooks frequently. The children moved about very little and were taught in groups. Emphasis was on aesthetic subjects and there were higher discipline problems than in the other two groups.

Barker-Lunn (1970) also investigated teacher styles and found 2 clusters, one similar to Bennett's informal, and the second similar to Bennet's formal. It appears then, that teaching styles as described above are related to the behaviour of pupils within the classroom and therefore the behaviour of pupils whether affected by teacher style or not requires close examination as a potential influence of gender differences in mathematics achievement.

Consideration of the relationship between teaching style and pupil progress has led to a lengthy debate as to whether the unit of analysis should be the class or the child and this debate continues (e.g. Gray and Satterly,1976; Bennett and Entwistle,1976). Aitken et al (1981) developed a method, using the class as the unit of analysis, to compare performance in a pre-test with a post-test. Results of the study showed that formal classes led to superior performance in English, informal classes in reading, and that neither style was superior in mathematics. As research shows that girls are better performers than boys in English, then girls may be better suited to formal teaching. But the absence of evidence for any superior style in mathematics is unhelpful in seeking possible reasons for boys' superior performance in this subject. Aitken's results (1981) have also suggested that pupils with low scores make the greater progress with informal styles of teaching whereas pupils with high scores do better with formal styles. These findings are contrary to those of an early study by Kemp (1955) and a later study by Warburton (1964) where it was reported that progressive styles correlated positively with pupil achievement in reading, writing and mechanical arithmetic. One possible explanation for these inconsistent findings, as Anthony has argued (1979) is that some studies only involved exceptionally gifted teachers in the use of the progressive style, whereas the equivalent group of traditional teachers was chosen from across a wider range. Other studies however, drew upon a random selection from the population of teachers.

4.82 ORACLE TEACHER STYLES

Unlike the studies upon which Anthony's re-analysis was based, the ORACLE study at Leicester (Galton,et al,1980) defined styles of teaching in terms of teacher-pupil interaction. Using cluster analysis on the data the researchers reported four teacher styles :-

1) Individual Monitors: were those teachers who set pupils individual tasks and spent a large proportion of their time telling the pupils what to do and marking their work. These teachers were mainly female younger than 30 years age.

2) Class Enquirers: were teachers who favoured class teaching,especially when introducing a topic, and who devoted proportionately more time to questioning pupils. These teachers were mainly males over the age of 30.

3) Group Instructors: were teachers who used groups of pupils for instructional purposes with the main emphasis placed on giving information and feedback on work. These teachers were mainly female over the age of 30.

4) Style Changers: were teachers who changed throughout the year from one style to another.

The distribution of teacher gender and age over the 'styles' is interesting to note and could represent 'cycles of fashion' in initial teacher training. Other studies have also found that the age and sex of teachers were related to teaching method (Barker-Lunn,1970; Gray,1978). Judged in terms of the performance of the pupils, the age of teachers was higher in successful styles than in the unsuccessful ones but the analysis suggested that the teaching style helps to explain the effects of age rather than the other way round.

The ORACLE project used the Richmond tests as measures of achievement (France and Fraser, 1975). When residual scores of pre-test to post-test in mathematics were compared, pupils of Class Enquirers (who were mainly male teachers) had made the most progress, while pupils of the Habitual Changers made the least progress. Pupils of Class Enquirers were also most successful in language skills, but other teaching styles fared differently across the curriculum. It is unclear what characteristics of this Class Enquirer style was conducive to mathematics learning. However, when pupils in the second year of investigation were tested, although pupils taught by Class Enquirers did well in the four rules of arithmetic, in practical mathematics the pupils taught by the Infrequent Changers also achieved the same levels of performance as pupils taught by the Class Enquirers. Teaching style rather than pupil type appeared to be the major determinant of a pupil's level of achievement in basic skills, but as the sex of the teacher was also closely related to the teaching style, teacher gender may also have been a factor affecting a pupil's level of achievement.

The 14 teachers who were observed for two consecutive years, all used the same style in the second as in the first year, even when teaching different children. Thus in no case did the balance of pupil types in a class impose a change of style on a teacher (Galton and Willcocks, 1983).

As stated earlier in the present study, the terms used to describe classroom teaching are problematic. Bennett's study (1976) and many other studies on aspects of classroom teaching have used the formal - informal description whereas the ORACLE study preferred a comprehensive description of classroom factors which in turn describe teacher styles and pupil types. It is apparent that there are two different aspects of classroom practice when 'style' is investigated 1) organisation of the classroom, and 2) aspects of the teaching itself. The two are often related in the ways one aspect influences the other. The following section reviews research not only on the organisation of the classroom and the teaching, but also on the effectiveness of different approaches to teaching.

4.83 EFFECTIVENESS OF TEACHER STYLE

Biggs (1983) used the term 'formal' in the sense of 'traditional' methods of teaching where teachers taught to the whole class and then left pupils to work individually through examples to consolidate the learning. In a study of 19 teachers in first schools Biggs reported that 16 teachers taught mathematics formally even though other areas of the curriculum were taught less formally. In middle schools, only 4 out of 20 teachers taught informally. Nash's observational study (1973) noted that teachers adopt more formal methods when teaching older junior children, and by the time that 12 year olds were taught activity methods were almost non-existent. The same study reported that teachers tended to ask closed-ended questions rather than open-ended, and this has been replicated by Barnes et al (1969) who demonstrated how this type of questioning can discourage discussion. The need for discussion to encourage girls to progress in the development of mathematical concepts has been argued earlier in this present review and it is possible that both the type of questioning used at primary school and the activity methods used may contribute to the superior performance in mathematics of girls up to the age of 12 years. If closed-type questions and less use of activity methods are used from the age of 12 upwards then girls' progress may be impeded.

Brophy (1979) has reviewed American research into teacher effectiveness and concluded that a structured curriculum was better than individual or discovery learning approaches. Those pupils who receive more instruction from the teacher do better than those who learn on their own (Brophy and Evertson, 1974; Evertson et al, 1978; McDonald and Elias, 1976). As boys are reported to get more attention from the teacher than girls, then it follows that boys would progress faster than girls who tend to work on their own. Various other studies have found performance and attitude generally to be higher in indirect or informal classrooms (Dunkin and Biddle, 1974; Tisher, 1970; Eggleston et al, 1976) but for creativity and imagination informal methods appear to be superior (Haddon and Lytton, 1968)

Various reports have criticised research in the past for too much concentration on controlled conditions and too little on classroom observation (Biggs, 1983), but the question arises as to the kinds of things that should be observed. Flanders (1960) examined ten kinds of behaviour, some about teachers (praises, asks questions, criticises) and students (response, initiation) or silent periods. Teachers were classified as either direct (authoritarian) or indirect (democratic) but the study failed to take account of classroom organisation or contextual variables which Bennett views as important determinants of teacher effectiveness.

Not all researchers, however, see teacher effectiveness in terms of types of questioning approach. Harnischfeger and Wiley (1975) disputed that teaching behaviour directly influences pupil achievement. Instead they argued that 'active' learning time on a particular topic was the most important determinant of a pupil's achievement. Hence Bennett's formal style is successful because it is the one where pupils spend most time on-task. In the case of mathematics, if girls spend less time on-task than boys, for whatever reason, then this time off-task may contribute to the inferior performance of girls compared to boys. However, it has been argued earlier that boys spend more time off-task than girls by engaging in misbehaviour and therefore one would expect boys who misbehave to suffer academically. ORACLE researchers tested this theory of 'on-task' influence with their data and found that time 'on-task' had a negligible effect on mathematics achievement, and therefore the amount of time boys spend on bad behaviour rather than on-task does not necessarily mean that their achievement is impeded. It may be, as suggested earlier, that the time boys spend on-task is of greater quality or intensity than when girls are on-task.

The ORACLE study (Galton et al,1980) found that a pupil's interaction with the teacher was mainly in a class situation (15.8%) with only a very small amount of individual attention (2.3%). When pupils were classified as high, medium or low attainers according to their performance on written tests, no differences were found in the amount of total pupil-teacher interaction according to achievement level, but low achievers did get more individual attention. However, no significant sex differences were found. In secondary schools less teacher-pupil interaction was observed overall in mathematics than in English and science. This reflects less class teaching and more individual work in mathematics than in the other subjects. Mathematics lessons tended to take the form of the teacher explaining a technique, then setting a task for the pupils to work on their own.

In the ORACLE study observation of teachers showed that statements and questions tended to be about routine and matters related to task supervision. Higher order questions were limited to whole class interaction which, as has already been suggested, involves greater participation by boys than girls. Coupled with this finding is evidence that at all levels, teachers ask different questions to boys than to girls e.g. boys are asked to reason while girls are asked to read out or to give factual answers (Spender,1982; Walkerdine and Walden,1982). Marland (1982) reported that teachers respond to their imagined differences between the sexes by their choice of subject content and by their way of praising, punishing and questioning (Barron and Marlin,1971).

4.84 SUMMARY

Many studies have used the terms formal and informal to describe classrooms whereas other studies e.g. ORACLE describe the classroom in terms of specific interactions classified in terms of teaching style and pupil type. The terms are problematic, but some similarities of teacher styles described were found between several studies.

Attempts to equate effectiveness with teaching style have received much criticism. It is impossible to say if the teaching style affected pupil behaviour and achievement, or whether the pupil's strengths and weaknesses determined the style. This criticism must be borne in mind when evaluating reports that informal teaching is beneficial in the teaching of arithmetic at the primary age level. If such reports are true, however, then this evidence may suggest that where gender differences exist at the primary age level, one style may suit one pupil gender more than the other, and this would be a strong argument in favour of single-sex classes.

At the secondary age level, no teaching style was found to be superior in terms of increased performance in mathematics, but in English formal teaching was found to be beneficial to the pupils. As girls are known to be superior to boys in English it may be that formal teaching styles suit girls more than boys.

Time spent working 'on-task' did not correlate with achievement and therefore it is the quality of 'on-task' time that may determine achievement levels in mathematics.

Some studies have reported that boys spend more time than girls 'off-task' and also gain attention from the teacher more often than girls do. The ORACLE study failed to support this finding but is is noted that ORACLE reported in relation to general curriculum areas and when separated subject by subject, time 'on-task' in mathematics may be different to 'on-task' time in English for the two sexes.

ORACLE also reported that teachers tended to ask higher order questions in whole class situations in which boys participate more than girls rather than in group or individual settings. It was also confirmed that boys tend to be asked to reason, while girls are asked factual questions. Thus the effects of teacher style on girls' underachievement in mathematics may depend on the type of classroom organisation in terms of class teaching or group work, and also on the type of questions asked of girls compared to boys.

The lack of participation by girls in whole class discussion has led many theorists to advocate the use of group work as a solution. Advice in the use of group work was included in the Plowden report (1967) but very little literature has been published on the effectiveness of group work. The following section discusses the little research on group work which has been published.

4.85 GROUP WORK

A discussion book published by the Association of Teachers of Mathematics (1984) reiterated the recommendation of the Cockcroft Committee (1982) that time should be set aside for discussion between both teacher and pupil, and between pupils and pupils. Discussion in groups or pairs is believed to encourage pupils to express opinions and discuss difficulties which, for girls in particular, could lead to greater confidence when using mathematics.

The ORACLE study Galton et al,1980) reported that very little cooperative group work, as envisaged by Plowden (1967), actually existed in the schools studied. Primary pupils were seated in groups but mainly worked individually, interacting on a one to one basis with the teacher. The ORACLE researchers believed that group work was advantageous in that it could reduce the likelihood of pupils making consistent errors as sharing ideas should lead to more errors being noticed. It has also been argued that working in groups enhances self-confidence and feelings of self-esteem. Some investigations have shown increased performance in problem-solving by use of group work (Joan Tough,1977; Douglas Barnes et al,1969), but other researchers have reported no such advantage (Bennett,1976; Biggs,1983).

The ORACLE study found in secondary schools, that mathematics tended to be taught in ability groups and pupils who were first to finish an exercise were given more examples to work through while the slower pupils caught up. This practice seems contrary to what one might expect i.e. the slower ones to need more examples for extra practice. Thus a great many children spend a lot of time working individually on undemanding tasks which may lead children to develop avoidance strateties for coping with this situation.

In Ward's study (1979), researchers also observed children working individually in all age groups from 5-11 and therefore little or no discussion between pupils took place. Because individual work was the prominent teaching method in mathematics, workcards were used a great deal. Given the nature of mathematics schemes, work cards fail to promote the discussion which, as mentioned earlier, may be essential for girls to progress in mathematics. If group work doesn't take place, and girls remain passive and lacking in.confidence then girls may be reluctant to interact with the teacher to answer questions or to ask for help. This suggests a need for single-sex classes where girls could feel more confident and willing to speak out in front of other pupils. Some evidence is available on the effectiveness of single-sex classes and is reviewed in the following section.

4.86 SINGLE-SEX VERSUS MIXED-SEX CLASSES

Delamont (1980) has reported that secondary pupils tend to segregate themselves into male and female groups and given free-choice would opt to sit in single-sex groups. Some research, already cited, has shown that boys receive disproportionate amounts of the teacher's attention. It follows that teacher behaviour may be directed to certain groups of boys only. The causes of the pupils' desire to segregate is unclear but, Delamont suggests it could be related to separating of the sexes in various routine matters such as school registers (which have nearly always shown boys listed separately from girls) and in routine organisation e.g. 'line up, girls first' (Delamont,1980). Delamont has pointed out that forcing pupils into mixed-sex groups leaves pupils unhappy and unwilling to work well. This segregation is not, however, common to all age groups. The ORACLE study reported that before transfer, segregation of the sexes was not apparent, most groups being mixed-sex. Even so, the patterns of pupil-pupil interaction did not differ significantly between the primary and secondary ages.

Several researchers have suggested that, to improve girls' performance in mathematics and science, they should be placed in single-sex classes even if not single-sex schools(Dale,1974; Shuard,1982; Harding,1981). As part of GIST (Smail et al,1982) Stamford school was divided into two halves and set by ability for mathematics - two A sets and two B sets. The investigation studied single-sex sets in one half of the school and mixed sets in the other. Girls in the single-sex set achieved higher mathematics performance than girls in the mixed sex, yet for boys mixed or single-sex sets produced similar achievement levels. When interviewed the girls reported that they felt freer to ask questions and to ask for more help from the teacher in the single-sex set. Boys were said to dominate the mixed set.

In another study, Steedman and Fogelman (1980) found that overall, girls in single-sex schools performed fractionally worse in mathematics than girls in mixed schools, and girls generally made less progress in mathematics than boys. In all-girls' Grammar schools however, mathematical performance at 16 approached that for boys in Grammar schools. Thus the results concerning single-sex versus mixed-sex schools are inconclusive with regard to the effect on performance in mathematics.

The need for either single-sex or mixed-sex setting of pupils to improve mathematics performance should not arise according to Hargreaves (1972) who has argued that to be effective teachers need to recognise the uniqueness of each and every teaching situation and choose the role and style most appropriate for the pupils, the task and the classroom situation. Indeed the Plowden Committee recognised that '*to achieve understanding it is neither desirable nor possible to indicate a definitive style for the teaching of mathematics, as different topics or pupils or a different teacher make different methods successful* ' (para 242). But the problem arises as to how the teacher can decide which methods will match the different circumstances that may exist. Trown and Leith (1975) investigated the suitability of different teaching methods for different pupil personalities. The results indicated that at primary level exploratory methods were less successful with anxious pupils whereas in secondary schools anxiety had little effect and extroverts were more successful with exploratory methods. These results have also been found with 10 and 11 year olds (Leith and Bossett,1967). It seems clear then that relationships between teaching style and method, personality, age and mathematics attainment are all likely to be factors affecting the underachievement of girls. Girls have been reported to be more anxious than boys in mathematics and therefore the effects of anxiety on achievement levels are considered in the following section.

4.9 Pupil Attitudes and the Effect on Performance Levels in Mathematics.

4.91 ANXIETY AND MOTIVATION

In a re-analysis of Bennett's data, Wade (1979) examined classroom behaviour and defined 'approachers' to be pupils who reduced anxiety by increased work activity and 'avoiders' whose defence mechanism might lead them to withdraw from classroom activities. The analysis examined pupils' attainment scores at the end of the academic year in relation to teaching style, initial levels of attainment and pupil sex, as well as personality. In formal classrooms children with high scores in motivation performed well irrespective of their levels of anxiety. In informal classrooms the less anxious of these motivated children performed better irrespective of their ability level. Of the less motivated pupils however, the less anxious showed superior performance. Thus 'approachers' achieved higher attainment levels under formal methods, but it must be noted that there were few 'avoiders' in informal classes. Thus it appears there is general agreement that a structured, formal but supportive approach is most suitable for anxious children, especially where anxiety is about academic success. Informal methods may help the least able children and also those who prefer autonomy.

The ORACLE researchers (Galton et al, 1980) used a shortened version of VIDIS, a motivation and anxiety questionnaire as used in Bennett's study, and found that pupil types and teacher styles did not affect the scores in motivation and anxiety, although anxiety about the teacher did fall during the academic year. This fall in anxiety was attributed to boys rather than to girls, girls being on the whole more anxious than boys but also more contented and highly motivated to please the teacher.

Eysenck and Eysenck (1975) failed to find a similar decrease in anxiety, there being an increase for girls from 7-15 years but irregular scores for boys. These conflicting results may be due to differences in instruments - Eysenck's was a test of general anxiety while ORACLE's was designed for a specific situation. It may be that boys become more reluctant than girls to admit their feelings of anxiety, particularly in the written form of a questionnaire. Nisbet and Entwistle (1969) have reported lower academic motivation displayed by boys at 11-13 years than at an earlier age and also found that well motivated pupils performed well, anxious pupils doing not so well. But there seems to be a circular argument here as to whether success increases motivation or whether high motivation increases success.

ORACLE researchers have suggested that high motivation is necessary for success particularly in teaching styles which leave the child to draw on his own resources. Trown and Leith (1975) found a negative relationship between anxiety and learning and this was also found by Entwistle and Cunningham (1968). As girls are more anxious, their learning might be impaired (Lynn and Gordon, 1961; Brown, 1970). However Eysenck and Cookson (1969) reported a U-shape relationship with low and high neuroticism scoring higher in achievement.

Crandall et al (1960) suggested that motivation varies from one curriculum area to another and so motivation in mathematics needs to be considered as a separate issue from general motivation. Entwistle and Wilson (1977) found mathematics undergraduates to be average on motivation but less extroverted and neurotic than other students. But if it is accepted that personality plays a part in determining academic achievement, this then leads to a further question of whether introverted and extroverted pupils react differently to any one situation. Eysenck and Cookson (1969) suggested that girls and low ability boys perform more highly if they are extroverted but that average and high ability boys are more successful if they are introverted, whereas Lewis and Ko (1973) reported that all better able children are more successful if they are introverts and all low ability are more successful if they are extroverts. It could be that low ability pupils need more help from the teacher and that extroverts are better equipped than introverts to demand such attention. Lewis and Ko (1973) also suggested there may be an age difference here, reporting that extroverts do better up to 12 years of age but at secondary age the introverts increasingly do better. Rushton (1966, 1969) believes this change-over to come between 12 and 15 years of age. Thus it appears that low ability and younger pupils do better if extroverted, higher and older pupils do better if introverted, and this may suggest an intellectual development rather than a chronological one.

Other studies have described personality in terms of 'reflective' or 'impulsive' behaviour; reflective people being slow to respond, and impulsive ones quick to respond. Both Kagan (1965) and McKinney (1973) found reflective pupils to be more successful in mathematics than impulsive pupils. In arithmetic, reflective pupils produce less errors and in problem solving they produce more efficient hypothesis strategies than impulsive pupils who use trial and error methods. It could be that children who are impulsive and work quickly (rightly or wrongly), have greater confidence in their ability than reflective pupils. As more girls are scored as reflective and introverted, any link between confidence and other personality dimensions such as reflection and introversion may be a pertinent issue to the cause of underachievement of girls in mathematics.

4.92 SUMMARY

Many educational reports have advocated the use of cooperative group work to encourage discussion in mathematics and this has been argued to be of particular importance to girls. In practice, however, little group work has taken place. In mathematics, individual work has been found to be the most commonly used organisation. Much of the individual work has been based on the use of workcards which, because of their design limits the opportunity for discussion. As girls are reported to be passive participants in the classroom, they are also unlikely to have opportunity for discussion in whole class teaching.

Secondary pupils segregate by choice into single-sex pairs or groups. It follows that, as boys receive more attention from the teacher for discipline purposes, girls have much less contact with the teacher and do not have the opportunity for discrete interactions. Although the argument for mixed groups in secondary schools appears strong, pupils have been reported to be unhappy if forced to mix and therefore it would seem that primary schools need to encourage interaction of the sexes, since although pupils at primary level are not segregated they rarely cooperate with pupils of the opposite sex.

One study has reported that girls' achievement improved in single-sex classes, while boys' achievement was the same as in mixed sex classrooms. Other studies however, have found the opposite and therefore the results are inconclusive. The initial achievement level of the pupils may be an influencing factor on the effect of single-sex groups.

The structure of a formal classroom appears to benefit anxious children, and an informal classroom to benefit the least able and those pupils who prefer autonomy. As girls are reported to be more anxious than boys, but more highly motivated too, then they may be more suited to a formal classroom given that anxiety has been reported to impair learning. The research findings reported above have relied on questionnaire studies and it maybe that boys don't admit their feelings on paper and are as anxious and motivated as girls.

When personality and achievement was investigated, extroverted girls and low ability boys were reported to achieve high performance levels and the researchers inferred that personality affects achievement although they might equally have concluded that achievement affects personality and self-confidence.

At higher school levels, boys were reported to be more confident and confidence was correlated with achievement. Girls were reported to display a lack of confidence in mathematics as early as in the pre-school. Evidence for a lack of confidence in girls comes, also from studies which report that girls underestimate their mathematical performance whereas boys tend to over-estimate theirs.

The interaction between personality, confidence and achievement in mathematics is therefore pertinent to the investigation of underachievement of girls, and the following section reviews the research evidence pertaining to pupil confidence.

4.93 PUPIL CONFIDENCE

Fennema and Sherman (1977,1978) have reported boys to be more confident than girls in their mathematics ability from grades 6-11. Higher correlations resulted between achievement and confidence in mathematics learning than between any other affective variable. But these results related to older students only ($r \approx 0.40$). Fox (1980), Fennema (1981) and Licht and Dweck (in Marland,1982) all reported that girls' lack of confidence in mathematics is present as early as the pre-school years. The APU (1981) found this lack of confidence in girls at age 11 when girls performed better than they expected to on mathematics tests while boys tended to overrate their performance. In the early studies, although lacking in confidence girls didn't report that they found mathematics hard. But the 16 year old survey results indicated the opposite trend. Girls now reported mathematics to be difficult. The APU secondary survey (1982) included a pilot study in which testers rated pupils on willingness to handle apparatus and their confidence and anxiety about success, on a scale of 1 to 5. Boys came out better on all but one of the aspects studied, but judgement was subjective and of the 31 testers, 24 were men.

Erlwanger (1974), in a series of case studies, found that children who were confident in mathematics gave different reasons for this confidence - one felt confident because he could develop his own set of rules, whereas another felt confident because he 'stuck to the rules' set out for him. The circumstances that results in one child being confident while another does not, so far remain unclear.

4.94 SELF-CONCEPT

Mead (1934) believed that a child must behave and develop a self-concept based on his/her perceptions of others' expectations of him/her. Many researchers consider self-concept to be multi-dimensional (Marsh et al,1984; Shavelson and Marsh,1985) but historically most interest has been focussed on general self-concepts (Wylie,1979). Dusek and Flaherty (1981) did investigate specific areas of self-concept and found adolescent boys to score higher in masculinity, achievement and leadership and to score lower than girls on congeniality and sociability. Boys also demonstrated a high self-concept in mathematics ability at this age.

Meece et al (1982) reported only small sex differences in mathematics self-concept during the elementary schooling but girls had lower levels of self-concept in junior and senior high school years. Meece asserted that as the decline in self-concept precedes the decline in mathematics achievement, then self-concept is likely to be a causal factor of the decline in achievement. A study of Australian 10 year olds (Marsh et al,1984,1985) obtained results which supported Meece's findings.

Marsh et al (1983) obtained a correlation of 0.55 between achievement and self-concept in mathematics but this high correlation was not found in other curriculum areas. In a later study, Marsh et al (1985) formed a model in which self-concept in reading (in which girls excel) and in mathematics (in which boys excel) are formed in relation to internal and external comparisons. In external comparisons the pupil compares his self perceived ability with the perceived abilities of others and uses this external impression to form a self-concept in each of the two areas. Internal comparisons occur when the student compares his self-perceived ability in mathematics with that of English and uses that internal impression as a second basis on which to form a self-concept in each of the two areas. If this model is correct then a higher perceived ability in mathematics than English would lead to high self-concept in mathematics but lower in English. Marsh and Parker (1984) did find that national average ability children in a low ability school had higher self-concepts than national average children in high ability schools and this appears to support the model, but there are likely to be home background differences because of the catchment area, so this conclusion may be based upon a spurious relationship.

4.95 ATTRIBUTION OF SUCCESS OR FAILURE

Success or failure in mathematics is used as a judgement by both teachers and peers and both groups of people make this judgement explicit to the pupil in their behaviour and attitudes towards them (Hudson, 1968). However, Dweck and Bush (1976) showed that too regular feedback on behaviour loses its meaning and is ignored even in relation to their work. Thus if boys receive a great amount of negative feedback for bad behaviour, then negative feedback on work will lose its meaning. Crandall (1969) in an American study found 8th grade girls were more sensitive to negative feedback and boys were strongly affected by positive feedback. Similarly, boys could blame failure in mathematics performance on lack of effort if they received a great amount of negative feedback for displaying a lack of motivation such as by bad behaviour. Because girls tended to be well behaved, any negative feedback was seen as a reflection on ability.

Various studies have suggested that whether a pupil attributes success or failure in mathematics to internal reasons (ability, effort, mood, personality) or external reasons (other people, task ease/difficulty, luck), these factors are an important influence on future learning (Whitley and Frieze,1985; Weiner,1980; Dweck and Bush,1976; Weiner et al,1971; Elig and Frieze,1975). Females are thought to blame internal reasons like lack of ability, whereas boys are more likely to blame external factors (Bar-Tal and Frieze,1977; Fennema and Sherman,1977; Nicholls,1979; Wolleat et al,1980).

In studies which have asked pupils to give reasons for success (rather than failure) in mathematics performance, girls tend to attribute external factors such as luck while boys attribute their ability (Heller,1978; APU Sec.Survey) although Wolleat et al (1980) also found that girls sometimes attribute effort for their success. Heller suggested that in failure situations those who attribute their result to low effort or bad luck will have greater expectancy in future tasks as the external factors change with each new situation, whereas those who attribute results to ability will have lower expectancy for future tasks. Dweck and Bush (1976) call this 'learned helplessness'.

Casserly (1975) found that many girls whose rate of progress in mathematics increased reported positive teacher influence as a cause of their success. Teachers in this study had high expectations for both girls and boys alike, yet Fox et al (1977) reported that parents and teachers believed mathematics to be a more appropriate activity for males than for females. When Nash (1973) investigated pupil's perception of the teacher he found that pupils described teachers under 6 pairs of constructs

1) keeps order - doesn't
2) teaches you - doesn't
3) explains - doesn't
4) interesting - boring
5) fair - unfair
6) friendly - unfriendly.

Pupils did not see themselves responsible for their own learning or discipline, but rather the responsibility of the teacher and the parents.

It appears possible, therefore, that the home has influenced the pupil in two ways : 1) in the development of confidence and a feeling of self-worth, and 2) in the development of pupil attitudes towards mathematics as a subject worthy of study. The home influences are investigated later in the chapter.

4.96 PUPIL ASPIRATIONS

A DES survey (Rauta and Hunt, 1975) found that girls reported that they would have liked to be good at mathematics and they believed that their parents would wish this too. High aspirers put more emphasis on these points and low aspirers tended to have a sense of failure. Low aspirers were concerned with marriage and the traditional female role whereas high aspirers were interested in careers with marriage later. One cannot assume a causal relationship here but there appears to be some kind of association between home-background and pupil aspirations.

Nash (1973) reported from a questionnaire study that low stream pupils wished to leave school as early as possible whereas high stream pupils were happy at school. As the pupils in the study had been at secondary school for less than 3 months, one would expect their primary school experience and/or their home background to have had some influence in the attitudes displayed by the pupils. Thus Nash concluded that children's attitudes are formed prior to leaving the primary school, and some support is provided by Gopal Rao (1968) who found strongly polarised attitudes towards mathematics in children by the age of 11, and also by Callahan in the US (1971), and Newbold (1977).

4.97 PUPIL ATTITUDES TOWARDS MATHEMATICS

Preece and Sturgeon (1981) have assessed the attitude toward mathematics of 2500 boys and girls aged from 10 to 15 years. The questionnaire consisted of 3 scales as, measures of liking of school, liking of mathematics, and mathematics as a male dominated subject. Preece and Sturgeon reported that girls in the final year at junior school had positive feelings towards mathematics but by the 4th year secondary age attitudes were less favourable. Boys' attitude measures fell too but not so dramatically as the girls'.

The APU (1981,1982,1983) reported that both girls and boys see mathematics as useful at the age of 11 but by 16 many more children, particularly girls, failed to view mathematics as useful.

Becker (1981) found that girls who chose mathematics at higher levels did so for enjoyment whereas boys chose through pressure from someone. There were no sex differences regarding liking the subject, the figure being about 30% for both girls and boys, but more boys viewed mathematics as useful. Russell's study of 'A' level mathematics students also found these results (1983)

Duckworth and Entwistle (1974) found deteriorating attitudes towards mathematics in the 6th form. This may be due to the style of approach to teaching mathematics. Walden and Walkerdine (1985) used an interview technique to assess attitudes of pupils in a school using a modern approach to mathematics called SMILE. Of the first year pupils, 61% of girls and 57% of boys liked mathematics. These pupils tended to be the 'better achievers' (both girls and boys), and the 'not so good achievers' who were mainly girls. Six of the boys who didn't like mathematics still felt they were good at it. When asked about SMILE, most girls reported to like it because it was familiar (like primary school) whereas the boys disliked it for the same reason, feeling they had 'moved on'. The majority of 4th year pupils disliked both mathematics and the teacher and felt that they themselves had no ability in the subject.

In an earlier study, Sharples (1969) investigated the attitude of 9-11 year old junior school children towards mathematics, reading, writing stories, art and physical education. Each pupil was required to choose which of eight statements they agreed with relating to each subject area. The 8 statements were of the type 'I hate it', 'It is most enjoyable'. The lowest number below 4 or the highest number above 4 was taken as the measure to be recorded, selection of items both above and below were unacceptable. The study was conducted in 4 schools which were considered to have a curriculum bias in favour of one of the subjects. Attitude to mathematics was least favourable in 3 out of the 4 schools, and last but one in the school with a curriculum bias towards mathematics. No significant differences were found by sex or age regarding preferences but attitudes to all the subject areas declined over age regardless of whether the teaching approach was child-centred or not. The study does however, assume that the 8 statements run along a continuum and the problem of interpretation of the language is not taken into account in the interpretation of the results e.g. the 'worst thing we do in school' may be related to difficulty rather than liking. Sharples also had more items relating to good than to bad which may have led to biased results.

4.98 SUMMARY

Research studies have reported a correlation between confidence in mathematics and achievement. Although these studies involved older students only, other studies have reported girls to exhibit a lack of confidence in mathematics as early as the pre-school years.

Girls report to lack confidence in mathematics at 16 years of age but at the same time they do not report to find mathathematics a difficult subject. Of the pupils who do feel confident the reasons given vary greatly from one pupil to another, and the circumstances resulting in a feeling of confidence or lack of it are unknown.

There is little evidence that girls hold a lower self-concept of their own mathematics ability in the early years of education, but the evidence increases in the junior and secondary age groups. This decline in self-concept may be a causal factor of girls underachievement and there is some evidence to support this argument but the reasons for the decline remain undetermined.

Girls are more sensitive to negative feedback from the teacher than boys, possibly because boys become used to receiving a greater amount of negative feedback for their bad behaviour. One result may be that boys blame a failure in mathematics as being due to lack of effort which they can put right in the future. Girls, however, who are generally better behaved and receive less criticism for behaviour, blame their failure in mathematics on a lack of ability.

When girls experience success in mathematics, researchers have reported that they attribute luck, over which they have no power, as the reason for success whereas boys attribute ability, which they can decide whether to use or not, as the reason for their success. Another researcher has argued that pupils tend to see teachers and parents, rather than themselves, as responsible for their learning. If this is true, then a belief by the teacher or parents that girls are less able to perform well in mathematics could influence the attitude of the pupil.

When female pupil high and low aspirers were investigated, low aspirers were reported to be concerned with the traditional role of marriage whereas high aspirers were concerned with a career first and marriage later.

It appears from the cited evidence that children's attitudes are formed prior to leaving the primary school. Girls have a positive attitude towards mathematics at the primary level, but a less favourable attitude at the secondary age. Although boys' attitudes drop too the fall is not so dramatic, and if the teaching style or the content of mathematics itself causes this decline in attitude, then there must be some aspect of attitudes which have a greater detrimental effect on girls than on boys.

Attitudes of girls by the age of 16 may be influenced by what many researchers claim to be a view of mathematics as a male dominated domain. The following section investigates the evidence for this view.

4.99 MATHEMATICS AS A MALE DOMAIN

Preece and Sturgeon (1981) found no sex differences with regard to whether pupils see mathematics as a male domain or not but sex differences were found on items relating to job needs. There were also few differences regarding parents' perceptions of mathematics. The study and others (Stallings,1979; Bush,1979) suggested that the most distinguishing factor between the sexes in attitudes to mathematics is girls' lower estimation of their own ability.

In 1969, Stein and Smithells discovered that 12th graders considered arithmetic skills to be more 'masculine' than did younger children. Such a view of mathematics as a masculine subject was also found by Weinrich-Haste (1979). Fennema and Sherman (1977) found that although 10th and 11th grade girls wouldn't accept mathematics as a male domain, they did display this attitude in their actions e.g. by not choosing to study mathematics. Fennema and Sherman also found evidence that stereotyping mathematics as masculine had an effect on other variables such as confidence and anxiety over mathematics, and the perceived usefulness of mathematics. Sherman (1980) reaffirmed these findings and explained the observed deteriorating attitudes to mathematics of girls from grades 8 to 11 by the social influences which increasingly made pupils see mathematics as more appropriate for boys.

Whether attitudes are related to achievement or not has been studied by several researchers. Selkirk (1974) failed to find any relationship and Jackson (1968), who reviewed the research literature, failed to find a significant relationship between attitudes and achievement. Knaupp (1973) couldn't find any evidence of a causal relation between attitude and achievement in arithmetic but Neale, Gill and Tismer (1970) did amongst lower-secondary age pupils, where the relationship was strong for boys.

Hart (1976) has reviewed several research studies and she found it difficult to determine whether attitude affects achievement or achievement affects attitude. Her study of 179 pupils found that less than 20% of the variance in attitude could be attributed to achievement variance. Many children already had a negative attitude towards mathematics.

If a pupil has a poor attitude towards mathematics, then this may prevent him/her from choosing to study mathematics at a higher level, regardless of ability. Females tend not to take advanced mathematics courses (Eccles,1984; Meece et al,1982). Judith Whyte has argued that this is because girls usually have to choose their subject at 13+ when girls are concerned with the traditional stereotype images associating 'liking mathematics' with 'masculinity' (Whyte,1983). This view of mathematics as a male domain, if it exists, could affect mathematics learning in other ways too to compound the problem.

Ernest (1974) has suggested that society believes boys to be superior to girls in mathematics and so a girl having a problem will 'muddle along' rather than seek help, and eventually will drop the subject. Some girls do survive however. The APU (1983) found that at 16 years of age more children than not feel that mathematics is more important for boys than girls, although it is boys who see mathematics as a boys' subject rather than girls. Lambert (1960) failed to find any significant correlation between mathematics proficiency and masculinity of interests but Elton and Rose (1967) reported that girls who were better at mathematics had more masculine interests. Fennema and Sherman (1978) found both girls and boys denied that mathematics was a male domain. It is possible that a view of mathematics as a male domain may influence a pupil's behaviour and expectations and the importance attached to success (Stein, Pohly and Mueller,1971). Dwyer (1974) has confirmed this in a study of children from grades 2 to 12. The extent to which interests and activities were labelled as either masculine or feminine contributed significant variance to reading and arithmetic scores of both sexes, but the effect was stronger for boys. The effects were stronger than those of liking/not liking the subject. For these findings to be a contributory factor to girls' underachievement in mathematics, girls would have to see mathematics as a masculine subject. There is little evidence for this. However if it could be demonstrated that poor attitudes in girls were related to poor achievement, the problem would then arise as to whether girls' attitudes can be changed. Patterson (1980) suggested that they can.

It appears that the relationship between the many facets of attitude is complex. Furthermore, by the nature of their research design, attitude investigations can only suggest relationships; they cannot explain the causes for such relationships.

4.10 Influence of the Home on Achievement in Mathematics

Results of various studies have indicated a link between pupils' attitudes towards mathematics and the choice of it at higher levels of study, and parents conception of what level is desirable for their children (Lantz and Smith, 1981). Other studies have shown a bias in favour of boys in the amount of parental encouragement to study mathematics (e.g. Fennema and Sherman, 1977; Luchins and Luchins, 1980). There is also evidence that children's educational achievement generally is related to parental attitudes and interest (Douglas, 1964; Plowden, 1967). The effects of parental occupation and education, poverty and family size on the progress of older children are well documented (e.g. see review by Mortimore and Blackstone, 1982) but little is known about how parental help affects skills at the earliest stages of school life, and whether parental help differs between boys and girls.

4.10.1 PRE-SCHOOL EXPERIENCE

Blatchford et al (1985) have investigated educational achievement in the infant school. The sample contained nursery classes of 33 nursery schools in ILEA multi-racial areas during 1982. The area was working-class and the study involved 343 children - 171 white, 106 Afro-Caribbean. The results indicated that just prior to entry into school the children had wide variations in their skills in literacy and numeracy. On entry, girls had higher literacy and numeracy skills than boys. Studies such as the National Child Development Study (Davie, Butler and Goldstein, 1972) reported that at 7 years there is a significant gap in these skills in favour of girls and the Blatchford study suggested that the difference is present at school entry. Blatchford's results show children's literacy and numeracy skills on school entry to be related to several aspects of home background and in particular the educational qualifications of mothers and parental awareness of home influences on educational success.

4.10.2 PARENT ATTITUDES

Parental attitudes and behaviour towards the different sexes may affect achievement in school by encouraging boys to be exploratory, independent and seek hobbies which develop mathematical and spatial skills which is denied girls. Gopal Rao (1973) reported a significant correlation between parent's and children's attitudes towards mathematics. Parents (especially mothers) may pass on their own fear of mathematics to their daughters as mothers may act as role models for daughters. Various Research studies have indicated that parental attitudes are related to a childs social and academic progress in school (Douglas, 1964; Davie et al, 1972). Statistics are often stated as if a causal relationship exists but as attitudes are notoriously difficult to define and to measure, the relationship between attitude and subsequent behaviour is problematic. Very little evidence exists as to the contribution the child makes to the interaction.

Finn (1980) investigated child interactions and cognitive development. Using a Draw-a-person Test the results indicated that boys' performance in mathematics was not related to the father's cognitive actions and attitudes but that girls' performance was related to father's attitudes. Mothers seemed more concerned with school grades, but there was a social class difference. Douglas (1964) suggested that the superior performance of middle-class pupils may be partly influenced by the attitudes of their parents who may give them little or much encouragement in their work. This emphasis on parental attitudes also emerges strongly in the report of the Plowden Committee (1967) which reported parental attitudes to be an even more important factor than home circumstances (occupation, income, size of family) and school factors (size of class, experience of staff). Parental attitudes are however, closely linked to the material circumstances of the home.

The APU secondary survey (1983) investigated background variables of the pupil with academic performance and the resulting scores were, in decreasing order 1) prosperous suburban 2) rural 3) established manufacturing 4) less prosperous suburban 5) city centre. There have been several studies on school achievement in relation to pupils'socio-economic backgrounds based on father's occupation. A significant finding has been the higher aspirations of the higher socio-economic background pupils, regardless of ability, compared to those from a lower social economic background (Cornelius and Cockburn, 1978; Galton et al, 1980;

Rauta and Hunt,1975; Bynner,1972), although level of socio-economic background tended to reflect the educational attainment level of the parents. One suggestion to account for the link between socio-economic background and aspiration is that smaller homes may restrict study and parental educational abilities may stimulate or inhibit the child's interest (Bynner,1972).

4.10.3 INFLUENCE OF THE PARENTS

The influence of the father in the lives of men and women mathematicians has been referred to by several writers (Wiener,1953; Carlsmith,1964; Iacobacci,1970). Carlsmith (1964) has suggested that boys learn the conceptual, analytic approach to mathematics from a close, harmonious relationship with their fathers. In contrast, the thought processes of females are described as more global. In most cases of famous women mathematicians (e.g. Hypatia, Maria Agnesi, Sonja Kovalevsky) the father's influence, or that of another male relative was significant in the extent of the success attained (Iacobacci,1970).

The father, of course, is not the only parent, and investigations of mathematical creativity have also cited the mother as important in the child's creative development (Stein and Bailey,1973; Baruch,1972; Stein,1973; Helson and Crutchfield,1970). Both the father and the mother help to determine the psychological climate of the home (Aiken,1973). Parents in the manual occupation group give least educational support to their children (Ashton et al,1975, Baughman and Dahlstrom,1968). Links between socio-economic backgrounds, attainment, and age of leaving have also been well documented (Helson and Crutchfield,1970; Fraser,1959; Douglas,1964; Wiseman,1964; Douglas et al,1968; Husen,1967; Floud and Halsey,1957).

4.10.4 SOCIO ECONOMIC BACKGROUND

Witkin (1974) administered questionnaires to 3400 pupils in 36 secondary schools and from the results concluded that the influence of the family is felt in the way family background limits the extent to which a pupil uses the value systems presented by the school to good advantage. Working class pupils may accept the values but not be socially articulate enough to benefit from them, while middle class pupils may choose to reject them altogether. Thus there may be many parents who want their children to do well at school, but who have no idea of how to play this role of 'good parent' and who do not demonstrate the knowledge and attitudes appropriate to it (Musgrave, 1979).

The most obvious influences of home background were the material disadvantages associated with poverty - e.g. poor levels of health and nutrition, and overcrowded homes effectively exclude a number of children from educational success (Donnison, 1972). However, the lower average performance of children from working class families cannot be entirely accounted for in this fashion. Pupils from families in skilled working class occupations still achieved less well than those from middle class homes. King (1974) has found that schools with a higher proportion of working class pupils have higher levels of provision but still produce lower levels of attainment.

Cohen (1979) has studied changes in parents' expectations of their children over the period of the first term at school. Parents of 50 children from 5 primary schools were involved in the study, balanced for number of sons and daughters, and also sibling position. A loose structured interview method covered 1) child's personality 2) experience of pre-schooling 3) parents' knowledge of school, and 4) prediction of how the child would get on socially and academically. The parents' own experiences of education were also included. The results showed that most parents were good at predicting academic performance. Also it was found that regardless of parents being hard pushing, soft, etc. the children were not passive recipients of parental attitudes and could not be stopped from 'doing their own thing'.

A study by Heller (1978) found that boys, more then girls, saw a lack of parental help as causal to failure. Luchins' study (1981) revealed that many women said that most encouragement for them to succeed in mathematics came from family and parents, whereas male mathematicians felt teachers had encouraged them most. Cockcroft (1982) believes positive parental models to be important in encouraging girls to do well in mathematics.

Following pupil interviews the EOC reported that most pupils felt that they had made their own choice of subjects and that parents provided great influence on this choice. There was some evidence of pressure on pupils to stick to traditional subjects on the grounds of 'don't want to be the only boy/girl doing the subject'.

Cox (1979) argued that disadvantaged children can be helped successfully only if the interest and co-operation of parents is gained, and some support is provided by Newbold (1977), for example, who found that 80% of low ability children had parents who did not show any interest in the progress made in school.

4.10.5 SUMMARY

Research studies on a view of mathematics as a male domain have produced conflicting results. Generally however, girls tend not to report that they view mathematics as a subject for boys only but they do differentiate between the mathematical needs of girls and boys in their careers. Boys, however, do tend to view mathematics as a male preserve.

Some researchers have suggested that at the age of choosing which subject areas to study at higher levels, girls are influenced by external pressures and tend not to choose to study mathematics. Other researchers have reported that girls choose to study subjects they like whereas boys choose subjects which they feel will be useful to them in their future careers.

Parents encourage boys more than girls to study mathematics at higher levels, and pupil achievement appears to be related to parent attitudes and interests, occupation and education status. The differential effect of these parental factors on girls and boys is unclear. Pupils may perceive attitudes of their parents differently to the way in which parents view their own attitudes.

Parents are known to encourage boys to participate in certain hobbies which are conducive to mathematical development e.g lego play, while mothers may pass on a fear of mathematics to their daughters by acting as a role model in a similar way that female primary teachers may do.

Research findings suggest that girls' performance in mathematics is related to father's attitudes whereas boys' performance levels are not. The conclusions to be drawn from this evidence are complicated by socio-economic factors as manual workers, for example, are reported to give less encouragement to their children than middle-class parents. This is further complicated by home background status which also reflects the educational levels of achievement of the parents. The conclusion to draw, therefore, may be that an interaction of several factors is likely to have some influence on the mathematical achievement levels attained by pupils and hence likely to contribute to the cause of the underachievement of girls. However, the importance of pupil attitude on the effect of achievement in mathematics is unclear. While it could be attitudes which influence achievement, it could equally be achievement which influences attitudes.

4.11 Summary of the Literature Review.

A vast amount of literature on sex differences in mathematics has been published in recent years, and many different, although by no means all, aspects of the problem have been reviewed here. Biological factors may have some influence on mathematical achievement but are not sufficient in themselves to explain the cause of girls' underachievement. There is some evidence of developmental stages of cognitive ability and that training has had little effect on accelerating cognitive development. Different methods of teaching mathematics - discovery, drill, etc. - have all been found useful for different aspects of mathematical attainment but seem to be effective in different ways according to the personality of the learner (extroverted boys preferring discovery methods but introverted girls preferring class teaching).

Analysis of errors made by pupils may highlight classroom variables which have led to the establishment of such errors e.g. teacher behaviour, use of technical language, etc. Such errors have been investigated using a classificatory system and by interview methods. Pupil behaviour types change from year to year and vary with the curriculum area in the secondary school. This suggests that either the teacher or the curriculum area is the major determinant of the pupil behaviour or possibly a combination of both factors.

A teacher's attitude is thought to affect the pupil's learning by acting as a model, particularly for girls in primary schools where most teachers are female. Primary teachers display a lack of confidence in teaching mathematics which affects the atmosphere in the classroom. Teachers have been found to hold pre-conceptions of children's ability and teach accordingly, and girls are generally thought by teachers to be poorer performers in mathematics. Teacher style affects the amount of interaction with, and attention given to, the pupils - boys getting more disciplinary attention.

Girls' lack of confidence and poor self-concept exists, even when their achievement level is not lower than the boys'. This may indicate a gradual build-up of various effects which manifest themselves in later years. Poor attitudes in girls do not correlate with poor achievement but may affect choice of subject at higher levels of education. Parental influence is considered important in determining the achievement levels of all children, middle class children having higher aspirations than working class children regardless of their ability.

Thus there seems strong support for the view that girls' underachievement in mathematics is influenced by socio-cultural factors regardless of the involvement of biological factors. Given the validity of this argument then, if ways of recognising such factors, when they occur, can be found and used by the class teacher, intervention programmes can be devised to eliminate inhibiting attitudes and practices that prevent girls from becoming a valuable source of mathematics specialists. Such findings may also be relevant to the needs of low achieving boys too.

In the next chapter, the details of the design of this present investigation are presented. The study, itself, looks at four of these socio-cultural factors identified during the review of research presented here. These four areas are:-

1. Teaching Style
2. Pupil Achievement and Assessment
3. Pupil and Teacher Attitudes
4. Parental and Home Influences

CHAPTER 5

THE STUDY

5.1 Outline of the Study.

Girls' mathematical achievement is generally either the same or somewhat superior to boys until sometime between the ages of 10 and 13 years when a change takes place. From this age boys generally outperform girls. As shown in the previous chapter a survey of the research literature on sex differences in mathematics leads to the conclusion that two main areas of research have been neglected. First there has been little research on classroom observation or on attitudes which focus on sex differences, and second, there has been little published work on analysis of errors in mathematics tests with respect to variations in types of error as a result of sex differences.

Many of the theories relating to the cause of sex differences in mathematical performance are based on the conjecture that differences in pupil behaviour exist within the classroom. Other theories are based on differences in attitudes and particularly to how these attitudes affect subsequent behaviour. It seems, therefore, that there is a particular need for an observational study in the classroom of pupils behaviour while doing mathematics.

The present study attempts to discover whether the treatment pupils receive in the primary classroom can contribute to an explanation of the trend for boys' performance in mathematical tests from the age of about 10 years to improve sufficiently to surpass the performance of girls. This present investigation of 5 to 13 year old pupils involves several sub-studies which link together. To investigate behaviour, an observational investigation, as used in the ORACLE study (Galton et al,1980), was used to record pupil behaviour in the classroom during mathematics sessions only. Teachers were also observed using a scheme which was specifically developed for the present study so that the focus was relevant to mathematics rather than to general curriculum areas. A mathematics assessment test was administered to pupils and the resulting scores ranked in order to select 3 boys and 3 girls (high achievers from above the 66th percentile, medium achievers from between the 33rd and 66th percentile, and low achievers from below the 33rd percentile) from each of 33 classes as focus pupils for observation.

Teachers' ratings of pupils' achievement in mathematics were collected to compare with the test results. The test results were used in an error analysis of each of the items in the test to see if these errors were related to gender differences either within particular mathematics topics or in the particular types of errors that occurred.

Testing of infants presents somewhat different problems to those encountered in the testing of junior children, partly because of undeveloped skills in writing and comprehension , and partly because of the short span of concentration demonstrated by infant pupils. To cope with these differences the infants were presented with the test orally while the older pupils were given a written test. Six children from 33 classes including infants, second year junior and second year secondary age were observed from Autumn to Summer of one academic year at approximately 3-weekly intervals. The teachers were selected to participate in the study by matching for gender and length of teaching experience. Care was also taken to include a cross-section of types of area (e.g. rural, city or suburban, and working class or mixed to middle class) in which the schools were situated for each of the four age levels. A post-assessment mathematics test was administered towards the end of the academic year.

To assess the attitudes of teachers, parents and pupils, various questionnaires were developed. With speed and ease of completion in mind, the teachers' and parents' questionnaires were designed such that the required response involved the selection of given words by means of underlining. A similar procedure was used in the ORACLE transfer study (Galton and Willcocks, 1983).

A parent questionnaire was prepared and sent to both parents of all the children in the classes which were involved in the observation study of behaviour. The teacher questionnaire was given to all teachers at the schools involved in the present study. Response to the teacher questionnaire however was poor, with some teachers refusing to complete the questionnaires and other teachers avoiding the opportunity to complete them or to hand them in for analysis.

Assessment of pupil attitudes was problematic. There was no adequate existing scheme whereby the attitude of 5 to 7 year olds could be established, mainly because of reading and vocabulary problems associated with testing young children. This has resulted in an innovatory method being developed for the present study - a projective method using cartoons as stimulus for short written responses. The cartoon attitude scheme was piloted in two schools and the final draft completed by junior children in the classes which participated in the observation study of behaviour. For the secondary pupils, a pupil attitude questionnaire, Likert style, was piloted and the final draft completed by the classes of secondary age pupils who were involved in the observational study. Questionnaires about pupil home background, hobbies followed, and career aspirations were administered at the end of the academic year to all of the pupils in the classes involved in the study.

5.2 Re-analysis of the Oracle Data

5.21 BACKGROUND

In 1975 a 5-year research project called ORACLE (Observational Research and Classroom Learning Evaluation) was established to investigate different teaching approaches and their effectiveness across the curriculum. Twenty-two schools, 19 primary and 2 secondary, in 3 LEAs were involved in a systematic observational study of teacher and pupils in the classroom. In the first year of the fieldwork 58 classes were studied. In each class 8 pupils, 4 boys and 4 girls, were selected on the basis of their performance on the Richmond Tests of reading, language skills and mathematics (France and Fraser,1975). Two pupils from each class quartile based on the combined total scores were chosen as targets for observation and each class was visited 6 times each term for one academic year. Questionnaires can be unreliable as a measure of teaching style as they tend to be answered in the idealist way rather than objectively and so ORACLE trained observers to follow a systematic schedule to observe behaviour in the classroom while also writing an impressionistic view of the classroom.

5.22 THE DATA SET-UP

About 400 pupils were observed in the ORACLE study, each for 54 lessons (6 lessons per term for 3 years). The main categories on the observation schedule related to information about pupil-adult interaction, pupil-pupil interaction, activities of the pupil, and activities of the teacher. The raw data consisted of the observations in each category on the schedule for each observed 'instant'. With a sampling interval of 25 seconds the interval between each pair of observations is too great for the 'instants' to be considered sequential and so the sets of observations were aggregated. New variables were then formed so that frequencies of compound classifications could be included in the study. For example it was possible to determine whether a pupil who was working on-task was also interacting with the teacher or a pupil at the same instant. This cross-tabulation procedure produced a total of about 270 variables including 50 that were defined by means of single categories with the rest defined by use of two or more categories. For each variable, the aggregated totals for each pupil was divided by the total number of observations recorded for that pupil to obtain means. In the original study, nine curriculum areas were distinguished (e.g. practical mathematics, reading, art) but these were reformed into three - mathematics, English, and topic. The data contained details of curriculum area, sex of pupil, LEA (which can affect teacher style by means of the establishment of certain policies), and age group of pupils.

5.23 HYPOTHESES

The present study also involves a re-analysis of the data pertaining to mathematics from the ORACLE study (Galton et al,1980). The results of the re-analysis were used to answer the following questions:

> 1. In mathematics lessons, do girls in schools which have a primary type of organisation behave differently to girls of the same age but in schools with a secondary type of organisation.

As the cross-over of gender differences in performance occurs between 11 and 13 years of age, i.e. at the secondary school age, it is possible that the organisation of teaching in a secondary school, whereby a pupil has many teachers throughout the week, contributes to the increased mathematical achievement of boys by being significantly different to the organisation of teaching in a primary school where, in general, pupils have one teacher to cover the whole curriculum.

In primary schools, the organisation of mixed-gender groups enables girls to glean their skills from boys as interaction can be carried out in whispers without attracting the attention of the teacher or of the other pupils seated at their tables. In secondary schools however, the ORACLE research study reported that mathematics tended to be taught on a one-to-one basis and again, as boys are reported to have more attention from the teacher than girls, this close supervision may lead to greater achievement in mathematics (Evertson et al,1978) and therefore boys have greater chance of progressing in mathematics than do girls.

Good (1970) found a relationship between opportunity to participate in classroom discussion and achievement but this was over all the curriculum areas together and it was interesting in the present study to determine if this finding applied to mathematics alone.

The need for girls to engage in discussion in order to make progress in mathematics was highlighted in the review of the research literature, and the type of questioning and the activity methods used in the primary but not the secondary schools may be why girls do so well up to the age of twelve. If closed-type questions are used at the secondary level then girls' progress will be impeded.

By comparing ORACLE's transfer schools, some of which were 8 to 12 middle schools, others 11 plus schools, the influence of school organisation on pupil behaviour of boys and girls may become clear. In particular, the study examines whether

> 2. boys receive more attention from the teacher than girls during mathematics lessons and whether boys spend more time on task and less time on routine matters than girls do in mathematics lessons.

According to the research literature boys receive more attention from the teacher than girls in two ways. Firstly by bad behaviour which requires the teacher to be physically present for discipline reasons. Adams and Biddle pointed out that pupils stop working when the teacher leaves the group, thus the extra attention for reasons of discipline leads to a) boys working more but also to b) boys being able to interact with the teacher when problems arise, and also to c) the teacher being close enough to spot errors when they occur. If girls are passive and attract less teacher attention then it may be that they work less 'on task'.

The next issue considered concerns differential treatment of girls and boys,

> 3. Do teachers praise boys more than girls in mathematics, and do teachers criticise boys more than girls for bad behaviour?

The influence in recent years of behaviourist psychology has led to teachers praising slow learners for a small amount of good work in order to encourage further good work to take place. Since, initially, the emphasis in school is upon language development (in which research shows girls are superior to boys), then boys will receive more praise than girls and come to have a high self-concept, whereas girls may believe that they are not so good at mathematics as they have less praise for their efforts. Some researchers have found that boys are criticised for discipline, but girls for work thus leading boys to feel that failure is due to 'lack of effort' and girls to 'lack of ability'.

The next issue examines the consistency of girls' behaviour across different curriculum areas.

> 4. Do girls belong to the same cluster type as boys for mathematics, and is a pupil's type consistent across all of the curriculum areas?

The ORACLE study found some sex differences in pupil types but the overlap of girls and boys in each type means that differences in pupil type cannot be solely a factor of gender. Teacher style was found to play some part in determining pupil behaviour in different curriculum areas in the secondary schools, but the primary data was not analysed by curriculum area and such analysis would be useful to the present study. The effect of pupil type on achievement was not proven in the transfer study, but the primary study needs investigation in this area.

In order to investigate the above questions in the reanalysis of the ORACLE data the independant variables involved were:-

a) Age range of pupils attending the school

b) pupil gender

c) achievement level of the pupil

d) age of pupil.

5.3 Further Observations. The present study.

The data from the research project ORACLE was also compared to the findings from the present observational study to see if the behaviour of pupils has altered over recent years following the influence of new published schemes and texts in mathematics.

In the present study, the main hypothesis is that the cross-over of sex differences in achievement is due to a developmental factor which begins at the infant phase and builds up until it becomes manifest at 12 or 13 years of age; this developmental factor being related to the pupil's interactions with peers and with teachers

i.e. $|G-B| = f(\text{age} \times \text{interaction})$ *where G=girls' achievement*
B=Boys' achievement

Other hypotheses were also examined as part of the research:-

5.31 that there is a significant sex difference in favour of boys in performance on mathematics tests. This difference appears from the age of about 12 years and is limited to certain topics within mathematics.

5.32 that girls make more conceptual errors which impedes progress in mathematics while boys make computational errors which doesn't impede progress in mathematics.

5.33 that there is a significant difference in the behaviour of the pupils in mathematics when compared to other curriculum areas, especially English, and that within this difference there is a sex difference.

5.34 that boys receive more attention from the teacher, in particular more criticism as well as more praise, and that this frequency of attention is related to achievement in mathematics.

5.35 that teachers ask boys more open-ended questions in mathematics thus developing analytical thinking, but teachers ask girls more closed-type questions which relate facts and does not develop analytical thinking.

5.36 that the attitude of a teacher towards the pupil is related to the mathematical achievement level of the pupil. Female teachers have a more negative attitude towards mathematics than male teachers do thus transmitting a negative attitude to girls for whom the female teacher acts as a model.

5.37 that parent attitudes towards mathematics is related to the achievement of the pupil in mathematics. Parent attitudes towards the importance of mathematics for their child are different if the child is a boy than if the child is a girl.

5.38 that pupils' attitudes towards mathematics reflects the rate of progress in achievement, this attitude being influenced by the attitude and perceived attitude of parents, teachers and peers.

These hypotheses fit into three broad categories relating to 1) performance on mathematical tests, 2) behaviour of pupils and teachers within the classroom, and 3) attitudes. The present study investigates each of these three categories. The first category, on test performance, is presented in chapter 6, the second category, on behaviour, is presented in chapter 7, and the third category, attitudes, is presented in chapter 8.

5.4 Design of the Study.

5.41 SELECTION OF THE SAMPLE FOR THE INVESTIGATION

The aim of this research was to study the behaviour and attitudes of pupils and teachers, and attitudes of parents in relation to pupils' performance in mathematics. Part of the investigation involved the re-analysis of the ORACLE data to compare classroom behaviour in mathematics with classroom behaviour in other curriculum areas. Details of the re-analysis are presented in chapter 6. The second part of the investigation concerned a more detailed study of the performance and behaviour of pupils in mathematics lessons only. This second part of the investigation involved pupils of infants, 2nd year juniors (8-9 year olds), 4th year juniors (10-11 year olds) and 2nd year secondary (12-13 year olds).

The study was originally designed as a quasi-experimental study, to match teachers in each pupil age group for the variables of sex of teacher (male and female), length of teaching experience (high experience being greater or equal to 5 years and low experience being less than 5 years teaching experience) and location of school (city, suburban, and rural). This would have required involvement of twelve classes for each age range being a total of 48 teachers altogether. However, this task proved difficult to accomplish.

A letter outlining the study and requirements was sent to approximately 180 schools in Leicester. A copy of this letter is presented in Appendix 1. Schools with a high percentage of pupils with different ethnic backgrounds were excluded, with the exception of one, to avoid the effect of different cultural and religious backgrounds which have a strong influence on the roles of boys and girls. There were 86 replies received from the schools, only 18 rejecting participation. These 18 schools gave the following reasons for declining to participate in the study:-

NO REASON GIVEN	5
RE-ORGANISATION PROBLEMS	4
RE-DEPLOYMENT	2
UNSUITABLE GROUPING	4
INVOLVED IN ANOTHER PROJECT	1
BUILDING WORK	1
NEW MATHS SCHEME	1
TOTAL	18

Of those infant teachers who replied offering to participate, only three were male teachers, two of these being deputy heads who were gaining infant experience as part of their professional development. The 4th year junior respondents included only three female teachers, two of these being highly experienced. In addition, considerations such as the number of suitable teachers within one school and the school's location relative to the University also affected the final choice of the sample. Only one city school was able to participate in the study apart from a high multi-ethnic populated school of which a small study was undertaken. A total of 13 primary schools and 3 secondary schools took part in the study.

5.42 THE PRIMARY SCHOOL SAMPLE

The sample finally consisted of one multi-ethnic, one city, eight suburban and three rural schools. Within these schools the catchment area varied from those whose parents were mainly in professional/managerial occupations to those whose parents were mainly unemployed or in unskilled occupations. The information relating to parents' occupations was obtained from interviews with the headteachers who also provided details of the number of staff, pupils, and free dinners taken at the school.

A summary of the numbers of primary teachers in the study, and details of the teacher characteristics relating to gender and experience are presented in table 5.1.

TABLE 5.1 THE NUMBER OF PRIMARY TEACHERS IN THE STUDY.

		Infant	2nd Jnr	4th Jnr
Female teacher, high experience	≥5yrs	3	3	3
Female teacher, low experience	<5yrs	2	3	1
Male teacher, high experience	≥5yrs	3	3	3
Male teacher, low experience	<5yrs	1	2	3
Total = 30		9	11	10

It was stated earlier that the original intention in the present study was to have a quasi-experimental design with teachers matched across several variables. For the reasons stated above, this was not possible and the study had an opportunity sample and not a matched sample.

5.43 THE INFANT SCHOOL SAMPLE: THE CLASSES

Five of the infant classes involved in the study were situated in open-plan or semi-open plan areas within modern buildings. The other three classes were situated in closed classrooms, two being within the same school of an older type building, while the other class was situated in a mobile classroom at a school where the main building was of a modern open-plan design. One other infant class was involved in the small-scale study of ethnic minority pupils. This class was open-plan. All of the schools had playground and grassed areas within the school grounds, and all of the classes had access to a sink. Library books were stored within each class area and the classes had access to general infant mathematics equipment such as fixicubes and set rings. Only one class had a computer within the classroom for their sole use while the other classes shared a computer with other classes in the school on a rota basis. Only one class used a published mathematics scheme to any great extent; the other teachers either produced their own work sheets or they printed questions, clock faces, etc. directly into the children's workbooks. Number work tended to be taught in a mathematics slot rather than within a topic theme across the curriculum but oral mathematics i.e. spoken question and answer sessions with some discussion was sometimes used to end a teaching period.

5.44 THE INFANT SCHOOL SAMPLE: THE CHILDREN

The infant sample consisted of children from reception age up to top infants i.e. 6 to 7 year olds. One infant class had to withdraw from the study owing to organisation changes within the school and another class was unsuitable for testing mathematical performance owing to the high number of pupils from an ethnic minority background with language differences. The infant study, therefore, consisted of seven classes of which four had a female teacher and three had a male teacher. The mean age of pupils at the start of the study was 5 years 8 months, and the ages ranged from 5 years 0 months up to 7 years and 0 months. The majority of pupils were from the lower infant age range.

For the pre-test of achievement a total of 143 pupils were tested of which 80 were boys and 63 were girls. Table 5.2 shows the distribution of pupils across the classes with regard to the type of catchment area and the characteristics of the teacher.

TABLE 5.2 DISTRIBUTION OF INFANT PUPILS ACROSS TEACHER CHARACTERISTICS AND TYPE OF CATCHMENT AREA

Experience	Sex of Teacher	Middle Class	Mixed Class	Total
High ≥5yrs	Female	28	17	45
	Male	17	16	33
Low <5yrs	Female	42	0	42
	Male	0	23	23
TOTAL NUMBER OF PUPILS		87	56	143 *

**Two of the pupils were unable to complete the pre-test because of timetable restrictions and so the data for the analysis was based on 141 pupils.*

For the post-test, six TARGET pupils only from each class were administered the same test as was used for the first test. Owing to absence from school and to changes in class membership only 34 pupils instead of the full quota of 42 target pupils were re-tested. The six target pupils from each class were three boys and three girls selected as high, medium or low achievers according to their total performance on the pre-test. For each class, the range of total scores on the pre-test was divided into three achievement bands and a girl and a boy from each band were selected at random to be the target pupils. Thus the term 'high achiever' relates to the class level of achievement and not a national level.

5.45 THE 2ND YEAR JUNIOR SAMPLE: CLASSES

Three of the second year junior classes were situated in open-plan areas within modern buildings in suburban areas of Leicestershire. Two of these classes were in a school which had a policy of teaching logic as a curriculum area from the infant age and used a variety of mathematics schemes e.g. SMP and Peak, in the junior classes. Mathematics tended to be taught on an individual basis with pupils seated in groups. These groups, throughout one session, rotated around four different curriculum areas not unlike the 'Rotating Changers' in the Oracle study (Galton & Simon,1980). The other open-plan class participated in team-teaching and the children were assigned to different groups from lesson to lesson, but for mathematics the children always followed the SMG mathematics scheme.

Two other second year junior classes, each from a different school set within suburban areas of Leicestershire, were closed classrooms within a school which had some semi-open plan areas. Mathematics tended to be taught on an individual basis at set times designated as mathematics.

These lessons were based on the use of Beta mathematics books or on teacher directed supplementary work. Other teaching times were designated as mental mathematics work and this was conducted in a whole class situation.

Two classes were situated in mobile classrooms. One of the teachers grouped the children by ability for seating arrangements but taught on an individual basis. The other class was very formal in that the teacher taught the whole class from the blackboard, concentrated mainly on mechanical arithemtic, and then set the children an exercise of examples to work through individually. A queue of pupils was allowed to form for pupils to request help or feedback from the teacher. The class was very large, 41 in number, and the teacher reported to find grouping children to be a physical impossibility i.e. he felt his teaching was constrained by the environment.

The final second year junior class to describe was a closed classroom in a former secondary modern school building. Teaching of mathematics followed the Peak scheme and teaching tended to be whole class followed by individual working on exercises. The pupils were seated in groups according to achievement with the lower achievement level situated nearest to the teacher's desk.

The second year classes not described here are referred to in the section on ethnic-minority pupils.

5.46 THE SECOND YEAR JUNIOR SAMPLE: CHILDREN

The sample consisted of pupils of 8 to 9 years of age. The study involved eight classes of which four had a female teacher and four had a male teacher. For the pre-test of achievement, a total of 213 pupils were tested of which 107 were boys and 106 were girls. Table 5.3 shows the distribution of pupils across the classes with regard to the type of catchment area and the characteristics of the teachers.

TABLE 5.3 THE DISTRIBUTION OF SECOND YEAR PUPILS ACROSS TEACHER CHARACTERISTICS AND TYPE OF CATCHMENT AREA OF THE SCHOOLS

Experience	Sex of Teacher	Working Class	Middle Class	Mixed Class	Total
HE ≥5yrs	FEMALE	0	25 suburban	31 suburban	56
	MALE	0	11 suburban 36 rural	0	47
LE <5yrs	FEMALE	0	0	55 suburban	55
	MALE	28 suburban	27 suburban	0	55
TOTAL NUMBER OF PUPILS		28	99	86	213

Where HE = high experience ≥5 years teaching
LE = Low experience <5 years teaching

For the post-test some children were absent and others were present who had been absent from the pre-test. The total number of pupils who were post-tested was 100 boys and 93 girls, making a total of 193 pupils, twenty less than on the pre-test.

5.47 THE FOURTH YEAR JUNIOR SAMPLE: CLASSES

Five of the fourth year junior classes were in closed classrooms in older type school buildings. Other than this common characteristic, the classes were very different with regard to the method of teaching employed. One teacher used a mixture of teaching methods from formal class teaching to practical and innovative methods linking other curriculum areas. One class set the children to work individually through a programme of work selected from various mathematics schemes (e.g. Beta books, Nuffield), and the children were responsible for recording their own progress. One other class had a teacher who was particularly interested in computers and the children were encouraged to use the computer to work through problem-solving programmes. Another class had a teacher with a strong interest in science and who had worked in industry for some years. The pupils in this class experienced a variety of teaching methods. The room was surrounded with posters which were designed to encourage private study and investigations of a mathematical and scientific nature. The teacher used the computer for problem solving, and at various times would employ collaborative group work, working in pairs, individual work, and occasionally class discussion to 'pull together' the findings from the latter.

Two classes were in semi-open plan areas of modern buildings and the children were grouped by ability. The teachers used different mathematics schemes and books to select specific work for the pupils who were expected to work individually.

The one other fourth year junior class was in a mobile classroom with a teacher who was a mathematics specialist. A variety of teaching methods were employed and practical work and use of calculators played a significant role in the mathematics course.

The fourth year junior pupils not described here are referred to in the section on the small case study of ethnic-minority pupils.

5.48 THE FOURTH YEAR JUNIOR SAMPLE: PUPILS.

The sample consisted of pupils 10 to 11 years of age. Eight fourth year junior classes were involved in the study of which three classes had a female teacher and five had a male teacher.

For the pre-test a total of 203 fourth year junior pupils were tested of which 108 were boys and 95 were girls. Table 5.4 shows the distribution of fourth year pupils across teacher characteristics and the type of catchment area of the schools.

TABLE 5.4 DISTRIBUTION OF FOURTH YEAR PUPILS ACROSS TEACHER CHARACTERISTICS AND TYPE OF CATCHMENT AREA OF THE SCHOOLS

Experience	Sex of Teacher	Working Class	Middle Class	Mixed Class	Total
HE ≥5yrs	FEMALE	0	40 rural	21 rural	61
	MALE	0	0	15 rural 28 suburban	43
LE <5yrs	FEMALE	0	0	26 suburban	26
	MALE	21 city	27 rural	25 suburban	73
TOTAL NUMBER OF PUPILS		21	67	115	203

Where HE = high experience ≥5 years teaching
LE = low experienc <5 years teachinge

As with the second year sample, some pupils were absent from the post-test while others were present only for the post-test. 93 boys and 88 girls, 181 in total, completed the post-test, twenty-two fewer than on the first occasion.

5.49 THE SECONDARY SCHOOL SAMPLE: CLASSES.

Three secondary schools were selected to participate in the study because of their differences in location and in their approach to teaching mathematics. School A was a city school containing pupils from 11 to 18 years of age and consisting of a catchment area of homes with a high degree of social problems. The school was an old two-storey building with stone stairs and 'closed' classrooms, and the teaching involved the use of traditional text books and blackboard. There were numerous discipline problems and the absentee rate was high. Pupils were 'set' for mathematics. School B was a suburban school with a low absentee rate. The pupils, within the age range 11 to 14 years, came from mainly privately owned houses. Teaching was semi-traditional with the use of textbooks and blackboard, and the classrooms, although 'closed', tended to have their doors left open. Pupils were 'set' for mathematics. School C was an open-plan rural school housed in a modern building. Pupils were taught on an individual basis using schemes of work which were produced by the mathematics team at the school and which used a practical approach to mathematics. All groups were of mixed ability/achievement. The catchment area was very mixed in terms of the type of housing, there being an old established part of the village as well as the development of large new estates of privately owned houses.

A summary of the number of secondary teachers in the study and details of teacher characteristics relating to sex and teaching experience is presented in table 5.5. Teachers of high experience were defined as having at least five years teaching experience, and teachers of low experience having less than five years teaching experience.

TABLE 5.5 THE NUMBER OF SECONDARY TEACHERS IN THE STUDY

		2nd Secondary
Female teacher, high experience	⩾5yrs	2
Female teacher, low experience	<5yrs	3
male teacher, high experience	⩾5yrs	3
Male teacher, low experience	<5yrs	2
Total number of teachers		10

5.50 THE SECONDARY SCHOOL SAMPLE: PUPILS

The sample consisted of pupils of 12 and 13 years of age. Ten secondary age classes were involved in the study of which five classes had a female teacher and five a male teacher.

For the pre-test of achievement, a total of 210 second year secondary pupils were tested of which 128 were boys and 82 were girls. Table 5.6 shows the distribution of second year secondary pupils across teacher characteristics and the type of catchment area of the schools.

TABLE 5.6 DISTRIBUTION OF SECOND YEAR SECONDARY PUPILS ACROSS TEACHER CHARACTERISTICS AND TYPE OF CATCHMENT AREA OF THE SCHOOLS

Experience	Sex of Teacher	Working Class	Middle Class	Mixed Class	Total
HE ≥5yrs	FEMALE	16 suburban	0	30 suburban	46
	MALE	18 suburban	0	21 rural	63
				24 suburban	
LE <5yrs	FEMALE	15 suburban	0	23 suburban	64
				26 rural	
	MALE	17 suburban	0	20 rural	37
TOTAL NUMBER OF PUPILS		66	0	144	210

Where HE = high experience ≥5 years teaching
LE = low experience <5 years teaching

Variation of attendance during the day of the tests resulted in there being fewer pupils taking the post-test. The actual post-test totals were 114 boys and 83 girls giving a total of 197 pupils.

5.51 THE SMALL SCALE STUDY OF ETHNIC MINORITY PUPILS.

The school with a high proportion of ethnic minority pupils was a new open-plan school with 70% pupils of Asian background, and an acting head during the year of the study. The school had a scale post for mathematics. The post holder developed her own schemes and assessment procedures for the whole school, and took out groups from each class to improve pupils' mathematical skills. The nursery, infants and first year juniors were in one building and were taught numbers from base 2 working up to base 10 by the end of the first year juniors. Work was mainly group work with a great deal of practical activities. The teacher in charge of mathematics was reluctant to show her schemes of work and assessments to people from outside the school including the researcher.

The language problems of the children meant that the instruments developed for attitude assessment were unsuitable and therefore only a small observation study of the ethnic minority pupils was carried out, involving one infant class, three second year junior clases and two fourth year junior classes.

5.52 SUMMARY

A total of 40 teachers were involved in the study of which 7 were from the school containing a high proportion of ethnic minority pupils (70% Asian). The main study which took place throughout the year involved 33 teachers. Owing to difficulties associated with transfer of children from one infant class to another, one of the *male infant teachers* had to withdraw from the study after one term.

The size of the infant classes ranged from 16 to 29 pupils with an average of 21; the second year juniors ranged from 11 (a team teaching situation) to 41 pupils with an average of 30; fourth year classes ranged from 22 to 43 pupils with an average of 30, and the second year secondary classes ranged from 19 to 32 with an average of 25 pupils.

A summary of the number of girls and boys who took the achievement tests at each age level is presented in table 5.7.

TABLE 5.7 NUMBERS OF PUPILS INVOLVED IN THE STUDY AT EACH AGE LEVEL

		2nd Year Junior	4th Year Junior	2nd Year Secondary
Test 1	Boys	107	108	128
	Girls	106	95	82
Post-test	Boys	100	93	114
	Girls	93	88	83
TOTAL		406	384	407

A summary of the timetable for each part of the study is presented in table 5.8

TABLE 5.8 TIMETABLE OF THE PROCEDURE OF THE INVESTIGATION INTO SEX DIFFERENCES IN MATHEMATICAL ACHIEVEMENT.

Year 1	Easter	Distribution of letters to schools and selection of the sample of teachers for the study.
	Summer	Visit to all schools for discussion about the demands made by the programme of the study.
Year 2	Autumn	Mathematics pre-test administered to all pupils and sample of pupils selected for for the observation study. Observation visits to all classes at six-weekly intervals. Teacher attitude questionnaires distributed.
	Spring	Observation visits continued. Parent questionnaires distributed. Pupil attitude instruments administered.
	Summer	Mathematics post-test administered to all pupils. Pupil background questionnaires distributed.

A summary of school characteristics is shown in table 5.9 and class characteristics in 5.10.

Table 5.9 THE CHARACTERISTICS OF THE SCHOOLS INVOLVED IN THE STUDY

	Multi Ethnic	City	Suburban	Rural	Total
Primary	1	1	8	3	13
Secondary		1	1	1	3
Totals	1	2	9	4	16

Table 5.10 CHARACTERISTICS OF THE CLASSES INVOLVED IN THE STUDY

	Open/semi	closed	mobile	multi ethnic open
Inf	5	2	1	1
2J	3	3	2	3
4J	2	5	1	2
Sec	3	7	0	
Totals	13	17	4	6

Results of the investigation into gender differences in mathematics achievement are presented in the following chapters.

CHAPTER 6

ATTAINMENT OF PUPILS IN MATHEMATICS TESTS.

6.1 The Infant Test.

In order to test the hypotheses as described in sections 5.11 and 5.12 a mathematical concept test, TOBE2 (Test of Basic Experience), was administered to pupils. The test compared performance of boys and girls on different topics within mathematics. This comparison involved the analysis of each item within the test. The first test, the pre-test, was given to as many reception infants as possible, and as early as possible following the start of attendance at school, in order to assess the pre-school achievement level of the pupils on mathematical concepts.

The mathematical concept test was also used to select three boys and three girls (each of high, medium or low achievement level) as main TARGETS for an observational study within the classroom. The same test was later administered as a post-test, to the target pupils only, so that the mathematical progress of the targets could be compared with the observed classroom behaviour of the pupils and the teacher.

According to hypothesis 5.11, the performance of the infant age girls should be equal to or superior to boys on these mathematics tests. Any observed differences should be specific to certain topics within mathematics.

6.11 THE TEST USED TO MEASURE INFANT ATTAINMENT

A test was required which would give some indication of the mathematical conceptual knowledge which pupils had gained from pre-school experience. It was considered necessary, in the present study, to have a test with a visual and oral presentation in order to overcome the problems associated with written language at the infant age level.

The Seventh Mental Measurement Yearbook (Buros, 1970) was consulted and from the critical reports contained in the book it appeared that two tests warranted further consideration - the Boehm Test (1970), and an American battery of tests called the 'Tests of Basic Experience', or TOBE (Moss, 1970). In the critical appraisal of TOBE, Cazden pointed out that although the test had some failings it was generally satisfactory given that tests for such a young age were rather rare.

To inspect the two tests, a copy of TOBE had to be obtained from America and an update of TOBE called TOBE2 (Moss, 1978) was subsequently found to be available. The Boehm test was a general test of basic concepts but the TOBE2 consisted of a battery of tests, one of which was designed solely for mathematical concepts. TOBE2 consisted of a booklet of pages each containing four pictures of which one picture represented the correct response to a set question. The design of multiple-choice reponse was considered suitable for testing children with limited writing skills, and the pictures of TOBE2 were clear. The TOBE2 mathematics test thus seemed to be the best infant test for mathematics that could be obtained.

Two levels of TOBE2 were available, one described by the author as suitable for pre-kindergarten to kindergarten age, the other for kindergarten to grade 1 (6+ year olds). As the sample in the present study were mainly of the lower infant age range, the lower level test was selected for use. The mathematics test consisted of 28 items of which the first two were practice items. Two other items were based on American currency (dollars and cents) and so these items were omitted. Thus the final test contained 24 items plus two practice items.

According to the author of TOBE2 the test items were selected on a combination of norm-referenced and criterion referenced criteria and each item tested a particular mathematical skill. The skill areas included:-

Order of Number

Counting

Geometry

Time and Money

Weight, Volume and Linear Measurement

Properties and Operations

Fractions

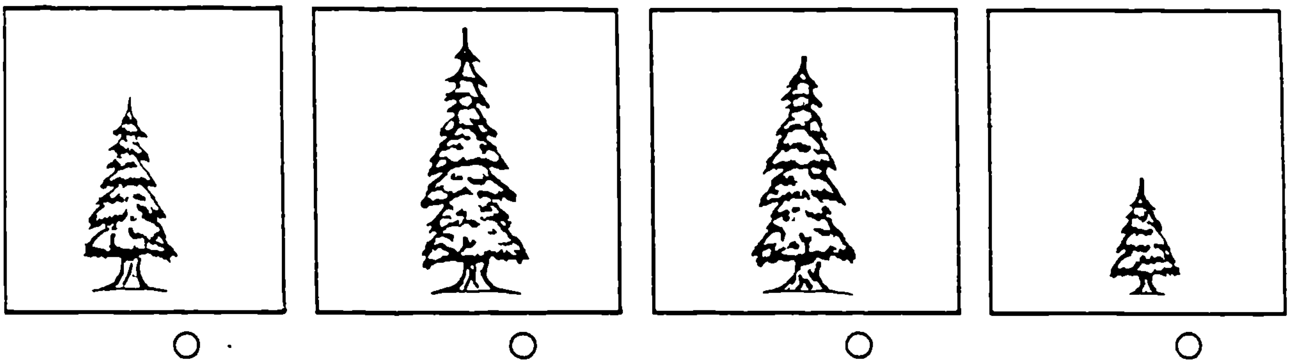
The manual also stated that all of the items ensure a lack of ethnic and gender bias and that the aim of the test was 'to provide an objective measure of the degree to which young children have acquired the concepts and experiences that are related to effective classroom participation in the early years of school'.

Standardisation and norms based upon American pupils were provided. No British norms were available but this was of no great concern in the present study as the test was not being used to compare pupils against a national measure.

Each item in TOBE2 consisted of a verbal stimulus and four pictured responses with the aim of testing concepts rather than factual information. No time limits were set by the author. The test items were presented in a booklet designed to minimise inattention by having just one item per page, and the pupils were expected to respond by marking a circle under the relevant picture. It was decided to change the method of administration of the test for the present study, as information relating to incorrect responses could not be collected using the suggested procedure. Details of the method of administration are presented in the following section.

6.12 ADMINISTRATION OF THE INFANT TEST

The pupils were tested individually, seated in a quiet area of their own classroom to ensure minimising the level of anxiety. Before the test began, the pupil to be tested was made to feel at ease by being encouraged to talk about themselves and their home. The class teacher remained in the classroom but was fully involved with other pupils. For the test, each item was presented orally and the pupil was instructed to point to the box which contained the correct answer. One item, for example, required the pupils to 'Point to the box with the tallest tree'.



No indication of 'right' or 'wrong' response was given by the tester as it was felt that the pupil's motivation might be affected if a series of 'wrong' responses was experienced. Two practice items were presented at the beginning of the test and further instruction was given if the pupil seemed unsure of how to respond.

The one-to-one test situation was considered preferable to that of group testing followed by marking of responses, as suggested by the test author. The procedure adapted was felt to be less disruptive to the class, as a whole, and less likely to induce anxiety in the pupils. A full list of the oral questions is presented in Appendix 2. The correct responses of the pupils were recorded item by item on a class record sheet. Pupils within a class were selected in a random order for testing.

The pre-test was administered at the beginning of the academic year when most of the pupils had just started school and then repeated only for the target pupils at the beginning of the Summer term after the pupils had been taught by the teacher for almost one whole academic year. Although it would have been preferable to administer the post-test at the end of the Summer term, the schools would have been engaged in school trips and sports days and the testing would have given rise to further disruption.

6.13 STATISTICS USED FOR THE INFANT TEST ANALYSES

The analysis of the test data was carried out using the Statistical Package for the Social Sciences, hereafter referred to as SPSS (Nie et al,1970), on the Cyber computer at Leicester University.

The measures and analyses included:-

THE T-TEST.

A t-test determines whether the means of two samples differ so much that the samples are unlikely to have been drawn from the same population. Various formulae are available depending on the particular circumstances of the study.

1. To compare the pre-test scores of boys and girls with a large independent sample (>30) the appropriate formula is

$$t = \frac{X_1 - X2}{\sqrt{\frac{\sigma_1^2}{n_1} - \frac{\sigma_2^2}{n_2}}}$$

where X is the mean score
σ is the standard deviation
n is the number of scores

Because this study has predicted the direction of the differences between the means of girls' and boys' scores (i.e. that infant girls will score higher than infant boys) a one-tailed test was appropriate.

ITEM ANALYSIS

The difficulty of items on the Tobe2 was measured as the decimal percentage of correct responses obtained from the whole sample of pupils. Thus a measure of 1.00 would be an easy item in which all children gave a correct response, and a measure of 0.00 would be a difficult item on which no pupil gave a correct response.

6.14 RESULTS OF THE ANALYSIS OF THE INFANT TEST DATA

The figures presented in table 6.1 suggests that the test did discriminate quite well between pupils of different achievement levels, but there were large numbers of children who correctly answered the more difficult questions. The distribution of girls and boys across high, medium and low achievement levels demonstrates that achievement levels were not gender related.

TABLE 6.1 DISTRIBUTION OF GIRLS AND BOYS ACROSS THE THREE ACHIEVEMENT LEVELS

	High	Medium	Low	N
Girls	14	18	7	39
Boys	14	19	11	44
TOTALS	28	37	18	83

None of the children appeared to be particularly anxious under the test condition. The younger pupils needed much more encouragement to respond, but many children approached the tester to ask if they could 'have a go' before it was their turn and so the level of motivation appeared to be high. The older pupils wanted to know how many questions they had correctly answered and were eager to compare each others' performance and turn it into a competitive game. Scoring the correct responses didn't appear to interrupt the flow of the testing procedure and short notes were made by the tester relating to reasons given by the pupil for a particular response (whether correct or incorrect).

T-TEST

TABLE 6.2 MEAN DIFFERENCES BETWEEN PRE-TEST SCORES OF BOYS AND GIRLS ON TOBE (Infant Sample)

	Mean	N
Boys	16.988	80
Girls	17.311	61

t=0.53 df=139 NS

A one-tailed t-test on boys' and girls' total scores on the TOBE2 yielded a t-value of 0.53 with 139 degrees of freedom. A result of this magnitude is not significant at the 5% level and no differences between the sexes were found. Thus at the infant age at the beginning of school life, no significant differences between boys' and girls' performance in mathematics total scores were found. This result is consistent with the findings of other research described in chapter 4 of the present study that girls are equal to or superior to boys in mathematical performance prior to the age of 12 years.

6.15 INDIVIDUAL ITEM DIFFERENCES (INFANT SAMPLE)

Although overall test scores did not yield a significant difference relating to pupil gender, the question arises as to whether there is a difference between girls' and boys' performance within the different mathematical skill areas tested by TOBE2.

Table 6.3 presents a comparison of girls' and boys' performance in the mathematical areas of Order of numbers, Counting, Geometry, Time and money, Weight, volume and linear measure, Properties and operations, and Fractions. The t-test analysis was based on the scores of 141 pupils on the pre-test of TOBE2.

Only two skill areas produced a significant difference between girls' and boys' performance viz. Time and money in which boys were superior to girls ($p<0.001, df=140$), and Fractions in which girls were superior to boys ($p<0.05, df=140$).

TABLE 6.3 SUMMARY OF T-TEST RESULTS ON PUPIL GENDER DIFFERENCES IN VARIOUS MATHEMATICAL SKILL AREAS

	Order of Numbers	Counting	Geometry	Time & Money
Possible score	3.00	7.00	2.00	3.00
Girls' Mean	1.77	5.52	1.48	2.58
Boys' Mean	1.74	5.45	1.48	3.14
Degrees of freedom	140.00	140.00	140.00	140.00
t value	0.2	0.3	0.98	3.58
Significance	NS	NS	NS	$p<0.001$

	Weight, Volume & Linear Measure	Properties and Operations	Fractions
Possible score	4.00	3.00	2.00
Girls' Mean	3.08	2.05	0.95
Boys' Mean	3.14	1.88	0.73
Degrees of freedom	140.00	140.00	140.00
t value	0.01	1.11	2.12
Significance	NS	NS	$p<0.05$

It appears, then, as the pupils were mainly reception infants, that sex differences in the two categories occurred prior to any great influence from the teacher and are likely to be the result of pre-school influences. The possibility exists that these pre-school influences included the differential treatment of boys and girls by their parents.

It should be noted however, that the number of items in each mathematical skill area was very small and it is possible that the items might have measured some non-mathematical skills which affected the success rate of the pupils. One possibility is that the test is sensitive to language skills. The sensitivity of test items to use of language is investigated further in section 6.16.

It is possible that different underlying patterns exist in the scores of TOBE2 related to ease/difficulty of the items. Ease/difficulty is investigated by obtaining the percentage number of correct responses for each item for 1) all pupils, 2) boys only, and 3) girls only. The rank order from ease to difficulty of all the test items is presented in table 6.4.

TABLE 6.4 RANK ORDER FROM EASE TO DIFFICULTY OF ITEMS AND SKILL AREAS CONTAINED IN THE TOBE2 TEST

SKILL	RANK of skill (1=easy)	ITEM NO.	RANK of item (1=easy)	ALL PUPILS	BOYS	GIRLS
Order of Numbers	6	8	14	0.68	0.67	0.69
		13	20=	0.49	0.53	0.45 *
		19	19	0.60	0.57	0.63 *
Counting	3	2	1	0.97	0.97	0.97
		5	12=	0.76	0.76	0.76
		6	18	0.62	0.60	0.65 *
		9	22	0.47	0.44	0.50 *
		10	8=	0.86	0.84	0.89
		14	6=	0.89	0.86	0.92 *
		16	4=	0.91	0.95	0.87 *
Geometry	4	7	3	0.94	0.92	0.97 *
		18	20=	0.49	0.46	0.53 *
Time and Money	1	4	10	0.84	0.87	0.81 *
		21	4=	0.91	0.90	0.82 *
		24	8=	0.86	0.87	0.84
Weight, Volume and Linear Measurement	2	1	2	0.95	0.96	0.94
		12	6=	0.89	0.92	0.84 *
		15	16=	0.64	0.61	0.66 *
		22	16=	0.64	0.63	0.65
Properties & Operations	5	3	23	0.41	0.37	0.47 *
		20	12=	0.76	0.71	0.82 *
		23	11	0.78	0.78	0.78
Fractions	7	11	15	0.65	0.61	0.71 *
		17	24	0.14	0.09	0.23 *

** Denotes a difference between boys' and girls' level of difficulty greater or equal to 0.05*

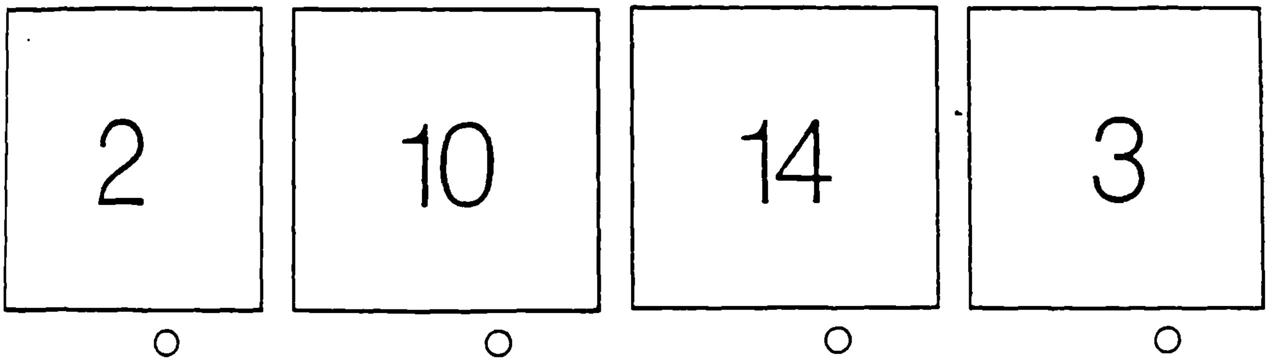
The average rank positions for each mathematical area was determined to compare the skill areas of mathematics (as tested by TOBE2) for ease/difficulty. The easiest section was 'Time and money' in which boys were superior to girls in performance. The most difficult area was 'Fractions' in which girls' performance was superior to that of boys'. From these results it could suggest that where boys, at the infant level, are superior to girls, there are at the same time many girls who are also able to be successful at the skill. However, where girls outperform boys, it is in an area in which both girls and boys find difficult. There are several possible explanations for this but remembering that these pupils have not yet had the influence of more than a week or two of schooling, the pre-school experience of the child must have, in some way, contributed to the differences in performance. It could be that more boys than girls are given a watch and that girls are encouraged to help with cooking which involves fractions such as half a teaspoon, etc. but this must remain conjecture.

Because of the limitations of the test in having so few items in each skill area it is possible that the individual items had some characteristics other than mathematical ones which influenced performance. Use of language would seem to be one possible source of variance in the test items. Reception infants with their different pre-school experiences might misinterpret the teacher's language in daily classroom interaction and this could lead to the occurrence of conceptual errors. These errors would be likely to continue until language is mastered at about 10 years of age. As girls acquire greater competence in cognitive aspects of language earlier than boys, the errors should affect boys more than girls in the primary years but this should change from about the age of 10 i.e. the age when previous research has reported boys' performance to equal girls' on mathematics tests.

In the present context one way of investigating the effects of language is to look at the demands made by different items, as reflected in the comments made by the researcher of difficulty expressed by pupils during the testing.

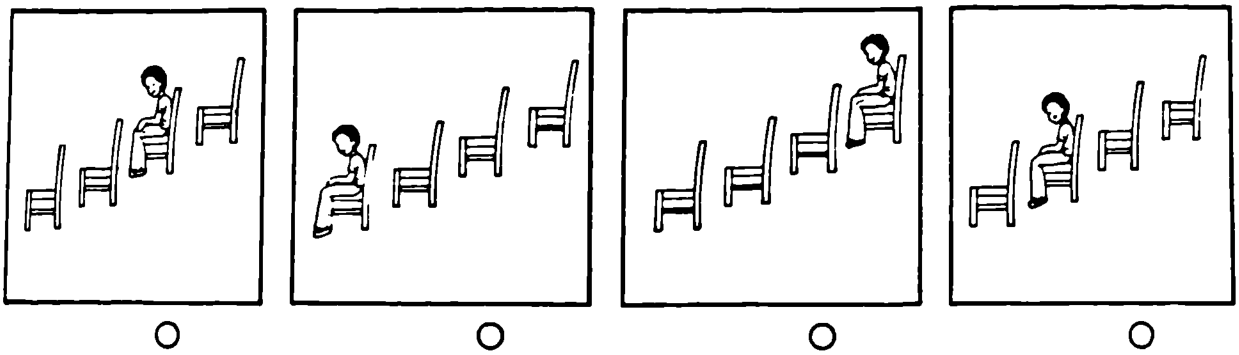
6.16 COMMENTS BY THE TESTER ON CHILDREN'S PERFORMANCE ON TOBE2

Item 2 'Show me the box which tells how many eyes you have'



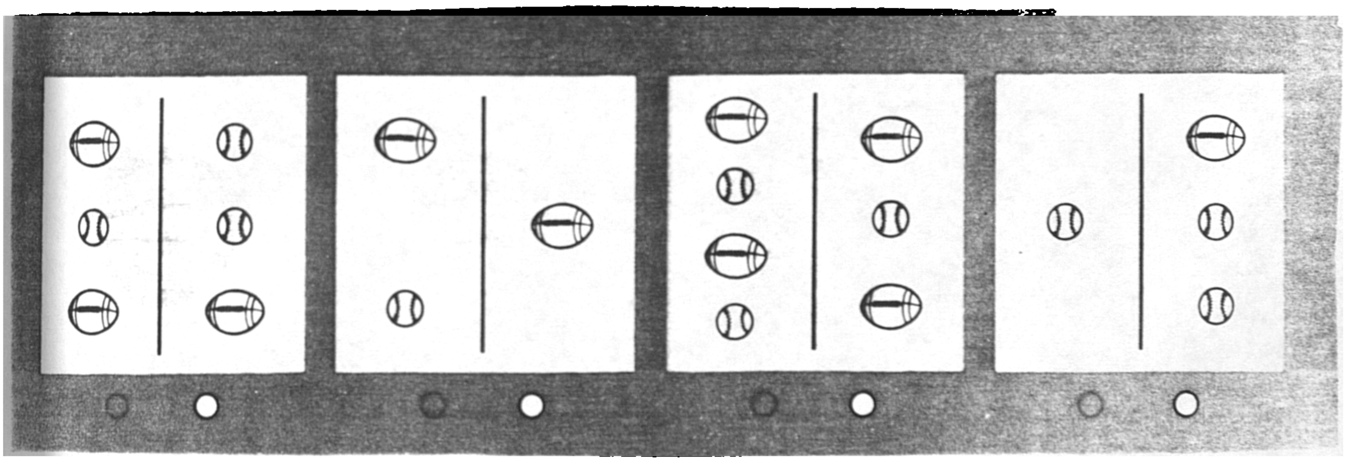
When first presented to the children a common response was to point to the number 10. When asked why they had answered 'that one' the children were unable to offer an explanation. When asked 'how many eyes do you have?' the same children replied correctly 'two'. After further interviewing of the children in this way it was apparent that *one of* the boxes which contained two digits, 10, was interpreted by the children, who were using a one-to-one correspondence, of the digit '1' for a closed eye and the digit '0' for an open eye. The problem of using appropriate language for infants to understand what is being asked of them is one which prevents the effective use of objective tests of this kind with such a young age.

Item 5. 'which box has the boy sitting in the second chair'



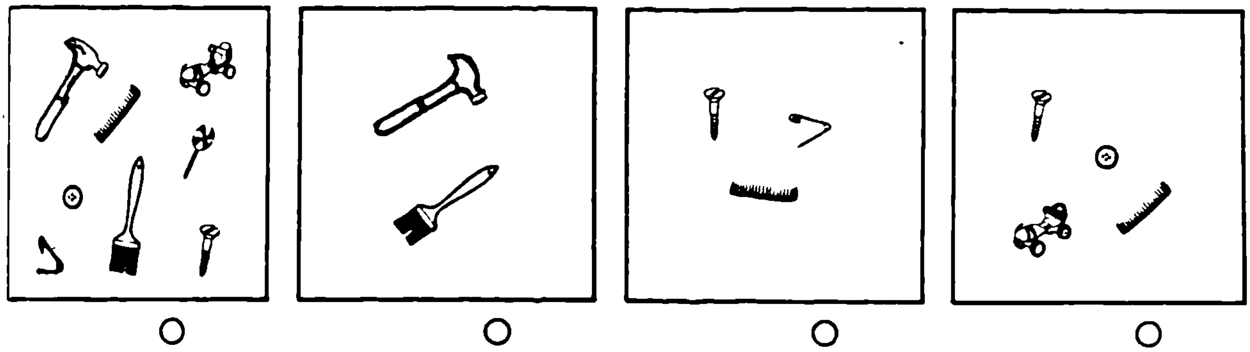
There were two possible answers to this question depending on whether the child counted from the left or from the right. If a possible correct response was given in the present study, the pupil was then asked which was the first chair in that picture. The author of TOBE2 failed to allow for this double choice response.

Item 6. 'which box has the same number of balls on both sides of the line?'



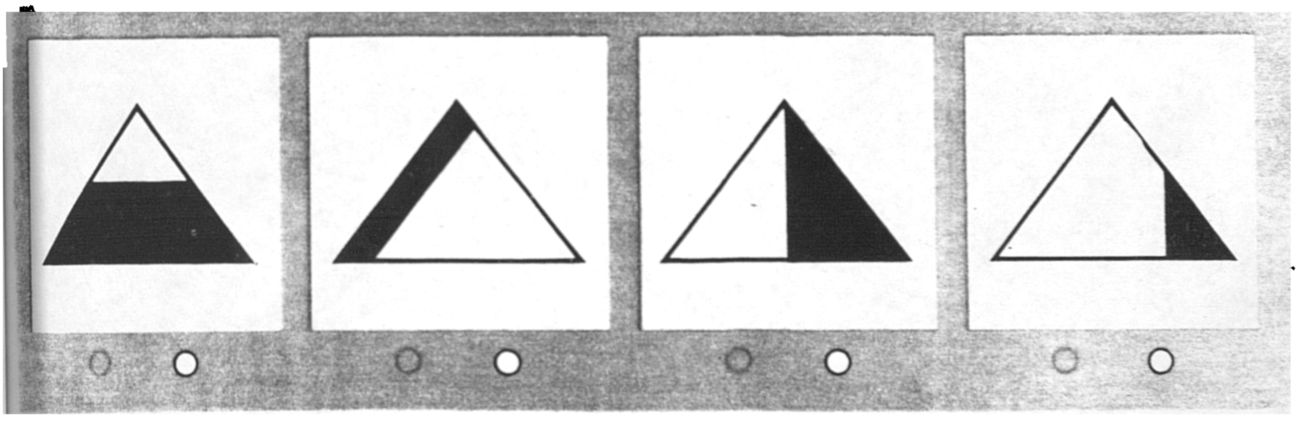
The children found this item difficult to understand. The balls were of different sizes and some children assumed that the balls had to be of the same size to be counted as equal.

Item 9. 'which box has the fewest things?'



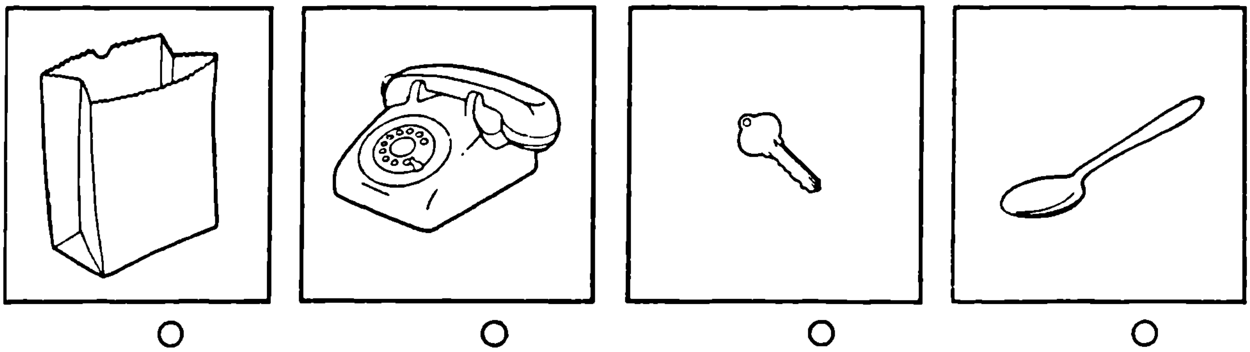
Many children pointed to the box with the 'most' things. There seemed to be a language problem here rather than a failure to be aware of quantity.

Item 11. 'Which triangle is half blue and half white?'



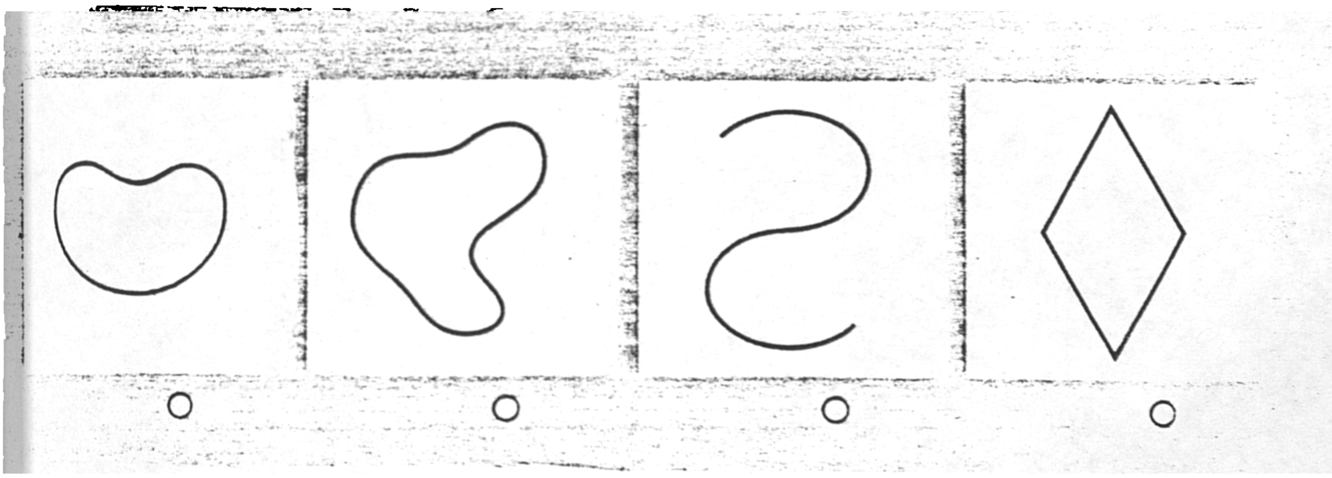
Many children interpreted the 'half' as meaning 'part blue and part white'. The importance of area was not appreciated at this age. Many of the older children did respond correctly but the interpretation was that two halves were identical in shape rather than area.

Item 12. 'which would weigh the most'



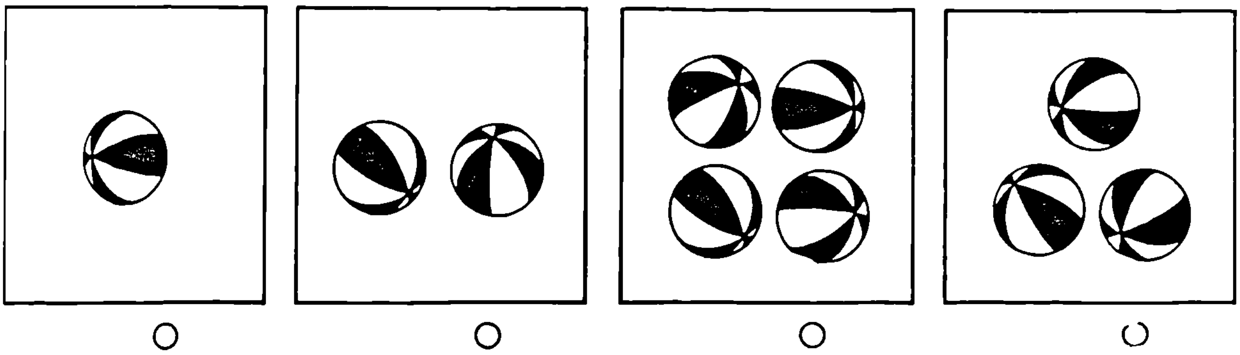
An empty bag, a telephone, key and spoon were the items pictured in this item and some children chose the bag because 'it was full of heavy shopping'. The test was changed for the post-test to inform the pupils that the bag was empty.

Item 18. 'point to a shape with some corners'



The concept of 'corners' was virtually unknown. Many children of pre-school age talk of 'going round corners in the car' when they really mean 'bends'. This is an example of pre-experience affecting the interpretation of language.

Item 23 'If you had 3 balls and one rolled away, how many would you have?'



The language in this item was ambiguous. Some children interpreted the question as 'how many before one rolled away?' while others as 'three balls after rolling away therefore 4 balls now'.

These few examples of the sensitivity of test items to language and presentation not only demonstrate how spurious results may be obtained by testing infant age pupils, but also supports the hypothesis that the increased performance of boys in mathematics which has been found by researchers at about the pupil's age of 11 may be due to a 'catching-up' on language skills necessary for written tests.

Thus there is evidence that it was the language used in presentation of the items of TOBE2, rather than an incorrect mathematical concept, which initially led to incorrect responses by the children. The item which was ranked as the easiest item, 'how many eyes you have' would have been ranked much lower if the tester had not asked further questions of the pupils to determine whether the pupils really knew the concept of the number 2. The method of presentation of TOBE2 in the present study was, therefore, superior to the method suggested by the author of the test in terms of acquiring knowledge about a child's mathematical achievement level. As most previous testing of infants has required some degree of language competence, it may be that investigation into gender differences in the scores of those tests were unreliable.

6.17 THE POST-TEST

The pre-test of TOBE2 was used for the analysis of pupil's mathematical performance in preference to the post-test as many pupils obtained maximum scores in the post-test. Given this ceiling effect, TOBE2 was, therefore, unsatisfactory as an assessment of progress in mathematics for the infant age range, and no further analysis of post-test scores was deemed to be of any use in the present study.

6.18 SUMMARY OF THE MAIN FINDINGS OF THE INFANT TESTING

Infant age children do appear to acquire a number of mathematical concepts at pre-school age as shown by the high number of correct responses to certain items within the areas of time and money; weight volume and linear measurement, and counting. Thus the influence of the home and of parents or pre-school experience has some part to play in the mathematical development of the children.

Item difficulty appeared to have been mainly linked to language problems such as the understanding of 'less than' and 'fewest' and 'corners'. Girls are therefore likely to perform better than boys at the infant age until boys develop adequate skills in language in order to perform as well as girls on written tests.

No significant differences were found in test performance total scores in relation to pupil gender.

There was some evidence that boys performed better than girls on easy mathematics items while girls showed superiority on more difficult items although the degree of difficulty of the items appeared to be more closely related to the language used in the items rather than the mathematical concepts which were being assessed. The presentation and wording of test items appeared to affect pupil performance considerably. With infant pupils, pre-school experience appears also to affect the interpretations that pupils put on the language used by the teacher when teaching and developing mathematical skills.

6.2 The Junior and Secondary Age Tests.

6.21 AIM OF THE TESTS

In chapter 5 the hypotheses 5.11 and 5.12 sought to test:

5.11 that there is a significant sex difference in favour of boys in performance on mathematics tests. This difference appears from the age of about 12 years and is limited to certain topics within mathematics.

5.12 that girls make more conceptual errors and this impedes their progress in mathematics whereas boys make more computational errors which does not impede progress in mathematics.

In order to test these hypotheses a mathematical concept test was administered to the junior and secondary age pupils to compare the performance of boys and girls on different topics, and also across different age groups up to 13 years of age. The test was administered towards the beginning of an academic year before the 'new' teacher had had a great influence on the pupils' performance. An equivalent test was administered as a post-test towards the end of the academic year. Gender differences were investigated in relation to both total test scores and scores in different mathematical skill areas.

Evidence presented in the review of the research literature leads to the expectations in the present study that girls should be superior to boys in mathematical performance at second year junior age, equal to boys during the fourth junior year and that boys should overtake girls and produce superior performances by the second year of secondary school. According to this hypothesis these gender differences should be limited to certain topics within mathematics. A selection of the test responses, were analysed item by item to investigate the presence of gender differences in relation to the specific types of error that occur. The test results of all the pupils would have been too numerous to be analysed with the time limitations of the present study, and therefore the test scripts of the target pupils only were used for the analysis. Hypothesis 5.12 suggests that girls should make more conceptual errors at all ages, leading to a build-up of errors which slows down the rate of progress in the learning of mathematics, while boys should make more computational errors of the 'blunder' type which do not impede progress in mathematics learning to the same extent.

The test was also used to select 3 boys and 3 girls (each of high, medium and low achievement level) as main TARGETS for an observational study within the classroom, and the information on the progress of the targets from the pre-test to the post-test was combined with the data on the behaviour of pupils and teachers from the observation study in order to explore the question of whether certain aspects of classroom practice appeared to have a differential effect on pupil performance.

6.22 THE INSTRUMENT

A test was required which would assess mathematical conceptual knowledge rather than pure computational skill of junior and secondary age pupils. The Seventh Mental Measurement Yearbook (Buros,1970) was consulted and from the critical reports contained in the book it appeared that the Bristol Achievement Tests (Brimer,1969) met this requirement. The tests are a battery of sub-tests one of which concerns mathematical concepts. To quote Morgan (in the Buros book) the Bristol mathematics test 'brings in imaginative new content, set in challenging and interesting forms, based on essential experiences in primary school mathematics: classification, order, number sense, sets, use of tabular material, and the language of graphs....it is heartening to see the emphasis placed on the general concepts, skills, and applications of learning required in the modern primary curriculum' (Buros,1970).

The tests were standardised on children from England and Wales and in the sample both age and sex were well distributed. The subtests were separately timed but printed so that one sub-test ends and another begins on the same page. Morgan warns that this could lead to complications in timing as some children might start the next subtest too early. The tests also make considerable reading demands on the pupils. Nevertheless, the benefit of the imaginative and modern content to the present study was valuable and the problems associated with reading could be accommodated by varying the method of administration.

The mathematics sub-test is made up of of five conceptual areas:

1. NUMBER including conservation of number, ordinal aspects, use of number bases, understanding of magnitude, place and direction. The items are based on a 'game' approach which, it was thought, would prevent the disadvantage to pupils who were without previous formal instruction in a particular aspect of mathematics.

2. REASONING including operation with sets and logical operations underlying algebra.

3. SPACE emphasising Piagetian types of item and leaning heavily on spatial representation and ideas of proportion.

4. MEASURING containing questions about angles, compass directions, use of scale, and practical measurement. At higher age levels graphical representation, probability and area are included.

5. ARITHMETIC LAWS involving the use of arithmetic processes.

Another commentator in the Buros book, Pilliner, praises the mathematics test but questions its use of language and suggests that in parts the problem of understanding the question itself is more difficult than the task of sorting and counting or whatever the question is designed to measure.

In the Bristol mathematics test involving the six sub-tests described above, different levels of the test are available for different ages from 8.0 up to 13.11 years of age. Each level has two parallel versions A and B. The test seemed therefore to meet the main requirements of the present study in that

1) it was a conceptual test rather than a computational test.

2) it contained different mathematical areas in the form of sub-sections of the test so that different topics within mathematics could be tested.

3) different levels of the test are available for different ages and so the second year junior to second year secondary pupils could all have similarly presented tests for comparison across the ages.

4) a post-test was available too in the form of the B version. However, the reservations expressed by the various commentators concerning its language were, as far as possible, accommodated by changing the advised procedure of administration.

The level 1 test was administered to the second year junior pupils, level 3 to the fourth year junior pupils, and level 5 to the second year secondary pupils.

A practice test was devised for the junior age ranges to familiarise pupils with the style of the questions. Teachers were asked to work through this practice test with the class during the week prior to the main test administration. A copy of the practice test is presented in Appendix 2.

6.23 PROCEDURE

Administration of the test

During the two days prior to the test, the teacher presented the practice test and discussed any difficulties or problems raised by the pupils.

For the actual assessment the pupils were tested in a whole class situation. The pupils were informed that they could ask for help from the teacher or the tester if they could not understand what the question was asking but could not be told how to work out the answer. Because the test was to compare boys' and girls' results rather than one particular class with another, it was agreed that the test procedure could vary to some extent from one class to another. Such decisions were left to the usual class teacher. Most secondary teachers insisted on a test situation of quiet and no conversation while some junior class teachers, where testing was thought likely to cause anxiety, allowed children to treat the test as a piece of work done within normal class conditions.

Each pupil was given a test booklet, and pupil responses were written. Time limits were set as follows:

	Levels 1 and 3	Level 5
Part 1	10 minutes	15 minutes
Part 2	15 minutes	15 minutes
Part 3	10 minutes	10 minutes
Part 4	10 minutes	10 minutes
Part 5	10 minutes	5 minutes

Pupils who appeared to be anxious that they were being too slow, were informed it was not expected that many pupils would manage to complete every section totally. It was found that this reassurance was required if motivation on the part of some pupils was not to fall away.

Test A was administered to all pupils at the beginning of the academic year when pupils were new to their teacher and therefore not influenced by them to any great extent, and test B was administered to all pupils as a post-test at the beginning of the Summer term after the pupils had been taught by the teacher for almost one full academic year. All pupils, rather than target pupils only, were post-tested to keep the testing procedure the same on both occasions, and to avoid any likelihood of pupils feeling that they were special cases.

6.24 STATISTICAL PROCEDURES

As with the infant test results, the statistical analysis was carried out using the SPSS package (Nie et al, 1970).

The measures and analyses used for the junior and secondary test data were:-

1. For the analysis of the junior and secondary test data it was necessary to compare the test scores on the first administration with the teacher's assessment of mathematical achievement of the children. For this analysis a correlation was performed on total scores obtained on test A with teacher assessments. In this situation a non-parametric correlation was preferable as it would determine whether two rankings of the pupils' attainment level were similar.

A correlation of teacher assessments with test B scores and of test A with test B scores was performed to investigate the possibility of pupil achievement being related to teacher pre-conceptions of a child's ability i.e. the Pygmalian effect.

2. Before the effects of male and female teachers on pupils' performance could be investigated it was necessary to ensure that there were no initial differences in test scores between the pupils who were to be taught by teachers of different gender. Accordingly a t-test was used to compare the mean scores of 'top achievers' in male teacher classes with those in female teacher classes. T-tests were also performed with middle achievers and low achievers. Since no direction of the differences was assumed, a two-tailed t-test was appropriate for use in the analysis.

3. An analysis of variance was used to investigate the effect of teacher gender, pupil gender and age level of the pupils on test performance. Analysis of variance is a measure which eliminates the need for numerous t-tests to compare the differences between mean scores. Following the analysis of variance t-tests were then performed on the significant differences to determine the direction of these differences.

4. Another analysis was also carried out in which the several mathematical skill areas were ranked from ease to difficulty. These rankings were then compared with the mean scores of girls and boys to investigate the influence of pupil gender on performance in difficult and easy areas of mathematics.

5. These gender differences might be found to exist mainly in certain classes rather than in the total sample of pupils. A two-tailed t-test comparing boys' and girls' test performance was also performed for each class separately.

6. To determine the types of errors of boys compared to girls in mathematics tests and to gain information about pupil's conceptual difficulties, a similar error analysis to that used in an Australian study, the Mount Druitt Longitudinal Study (Houghton and Low, 1982) was undertaken. The study investigated errors in calculation by first testing the errors and their frequency. Errors were then classified into error 'types' according to the apparent way in which the child had obtained the incorrect response. In chapter 4 the Mount Druitt study was criticised for failing to interview the children. In the present study, ideally the children should have been interviewed to obtain more accurate analysis of their thinking, but owing to the limitation of time and resources, classification had to be based on the model provided by the Mount Druitt study.

The percentage of girls' and boys' errors in each classification was calculated for each mathematical area and the results compared to see if at any age boys make more blunders or girls make more conceptual errors as theories described in the literature review suggest that they would do.

6.25 RESULTS AND DISCUSSION

Correlation of test scores with teacher assessments.

Initially, many of the teachers in the study were very reluctant to put an assessment of the children onto paper. Among their reasons was an insistence that it was against the school's policy to 'label' a child with a level of achievement, while others argued that the beginning of a new year with new children presented difficulties in giving a true assessment. One teacher, who insisted that she didn't like to 'label' a child, at a later date remarked of a pupil 'she's one of the brightest in the class'. Having discussed that this 'brightest' was a form of assessment the teacher agreed to place the pupils into achievement bands for the present study, provided that the other teachers in the school were not told of her assessment. Other teachers reported that they didn't wish to rely on the assessments and reports provided by the previous years' teachers.

The amount of pressure put on the teachers to provide an assessment was minimal and although reluctance was expressed, some teachers did provide written assessments by the time of the subsequent visit by the researcher. The result was that three second year junior teachers provided an assessment of their children, five fourth year teachers, and five secondary teachers. Correlations are based on the data from these teachers and the results are presented in table 6.5

TABLE 6.5 CORRELATIONS BETWEEN THE BRISTOL ACHIEVEMENT TEST A WITH TEST B, AND BETWEEN TEACHER ASSESSMENTS WITH TEST TOTALS

	TCH ASS/TEST A	TCH ASS/TEST B	TEST A/TEST B
2nd Yr Jnr	0.80	0.64	0.75
4th Yr Jnr	0.67	0.52	0.85
2nd Yr Sec	0.67	0.37	0.87

The second year junior teacher assessment yielded a correlation of 0.8 with the Bristol Achievement Test A score totals; the fourth year junior teacher assessments yielded a correlation of 0.67, and the second year secondary teachers also yielded a correlation of 0.67 with test A scores. These correlations are quite high which suggests that despite the anxieties and arguments against assessing the pupils, teachers were able to assess pupils' performance in mathematics even at so early a stage in the school year. The teachers were not requested to explain the basis on which they assessed their pupils therefore it is not known if they used reports from the previous teacher on which to form their judgements or if it was the first impressions gained at the start of the school term.

Teachers who showed an initial reluctance to assess the pupils may have been displaying a lack of confidence and a 'fear of being wrong'. Although this must remain conjecture, some support was found from the teachers' keenness to look at the test scores of the pupils and the subsequent comments to the researcher regarding confirmation of the assessments and offers of reasons to account for any discrepencies.

Another possible reason for the initial reluctance may be that the request for the assessments came at the beginning of the study when the researcher was a relative stranger to the teacher. After the first few visits to the school, a professional relationship between the teacher and researcher began to develop and teachers appeared to be more open in discussion.

Comparison between teachers' initial assessment scores and scores on test B at each age group yielded correlations of 0.64, 0.52, and 0.37, while correlations between test A and B for each age group were higher at 0.75, 0.85 and 0.87 for 2nd year juniors, 4th year juniors and second year secondary pupils respectively. These high correlations suggest that children's performance in the post-test was closer to their performance in the pre-test than to the teacher's initial assessment. There are two possible explanations for this. First that children may continue to develop at the same relative achievement levels (i.e. both high and low achievers perform accordingly throughout the year thus remaining high or low achiever) regardless or the teaching they receive. Secondly it may be that teachers' expectations lead them to treat pupils as high or low achievers based on the initial impressions i.e. the Pygmalian effect. To investigate these possibilities, evidence of the treatment pupils receive in the classroom is needed from the observation study which is presented in the following chapter.

While the pupils' achievement on the pre- and post-test were highly correlated, the question remains as to whether girls are generally the high achievers at the primary level, as previous research has suggested, and also whether pupils with a male teacher progress at different rates of mathematical performance than pupils with a female teacher.

For the effects of teacher gender to be examined it is necessary to be sure that the selected target pupils of male teachers were not significantly different from pupils of female teachers in the pre-test (test A) performance. A summary of t-tests comparing teacher gender with scores in different mathematical skill areas as measured by the Bristol Achievement test is presented in table 6.6

TABLE 6.6 T-TEST OF BRISTOL ACHIEVEMENT TEST A SCORES WITH TEACHER GENDER FOR PUPILS OF TOP, MIDDLE AND LOW ACHIEVEMENT BANDS

	TOP ACH			MIDDLE ACH			LOW ACH		
	t	df	sig	t	df	sig	t	df	sig
NUMBER	0.04	31	0.97	0.15	32	0.89	-0.24	31	0.82
REASONING	-1.30	31	0.22	-1.8	32	0.09	-0.49	31	0.63
SPACE	0.03	31	0.98	-0.34	32	0.74	-0.31	31	0.76
MEASUREMENT	-0.4	31	0.69	-1.08	32	0.29	0.34	31	0.74
ARITH. LAWS	0.52	31	0.61	-0.38	32	0.70	-0.76	31	0.45
TOTAL	-0.37	31	0.72	-0.76	32	0.46	-0.55	31	0.59

None of these results were significant at the 5% level and therefore it would appear that the sample of pupils of male teachers and the sample of pupils of female teachers were not significantly different in mathematical performance at the beginning of the study.

So far, it has been shown that the sample of target pupils of male teachers and female teachers were not significantly different in performance in mathematics and that the target pupils in each achievement band were placed with agreement between both the teacher assessments and the test scores. The next step was to investigate the effect of teacher gender and pupil gender on performance in mathematics at each age level. For this an analysis of variance was used on the scores obtained on the subsets, and the total scores on the Bristol Achievement Test.

3. Analysis of variance based on 221 cases

TABLE 6.7 SUMMARY OF THE SIGNIFICANT RESULTS OF ANALYSES OF VARIANCE OF TEACHER GENDER, PUPIL GENDER AND PUPIL AGE ON THE SCORES ON THE SUBTESTS, AND THE TOTAL SCORES ON THE BRISTOL ACHIEVEMENT TEST

TEST A

	TEACHER GENDER			PUPIL GENDER			INTERACTION		
AGE	2 Jnr	4 Jnr	Sec	2 Jnr	4 Jnr	Sec	2 Jnr	4 Jnr	Sec
Number p<	0.02	NS	0.001	NS	NS	NS	NS	NS	NS
Reasoning	0.001	NS	NS	NS	NS	NS	NS	NS	NS
Space	0.001	NS	NS	NS	NS	NS	NS	NS	NS
Measure	0.001	NS	NS	NS	NS	NS	NS	NS	NS
Arith	0.001	NS	NS	NS	NS	NS	NS	NS	NS
TOTAL	0.001	NS	0.030	NS	NS	NS	NS	NS	NS

TEST B

	TEACHER GENDER			PUPIL GENDER			INTERACTION		
AGE	2 Jnr	4 Jnr	Sec	2 Jnr	4 Jnr	Sec	2 Jnr	4 Jnr	Sec
Number P<	0.003	0.01	NS	NS	NS	NS	NS	NS	NS
Reasoning	0.006	0.006	NS	NS	NS	NS	NS	NS	NS
Space	0.001	0.001	0.009	NS	NS	NS	NS	NS	NS
Measure	0.006	0.020	0.030	0.050	NS	0.030	NS	0.010	NS
Arith	NS	0.010	NS	NS	NS	NS	NS	NS	NS
TOTAL	0.001	0.001	NS	NS	NS	NS	NS	NS	NS

Teacher gender had significant effect on nearly all scores at the second year junior age both at the pre-test and the post-test. This suggests that the previous analysis to ensure that pupil performance in male teachers' classes was not different from pupil performance in female teachers' classes at the beginning of the study was too conservative in that the pupils from all age groups were included in the one analysis. From the analysis of variance results in table 6.7 it appears that pupil performance of secondary age pupils was influenced by teacher gender but the influence on second year junior pupils is unclear owing to the biased sample at the beginning of the study. With the fourth year juniors, teacher gender had effect only at the post-test (i.e. after almost one whole academic year under the influence of the teacher), when the sections of Reasoning, Space, Measurement and Arithmetic Laws were all significant in relation to teacher gender. At the secondary age level teacher gender had effect in specific areas of mathematics - on Number and the total scores of the first test, and on Space and Measurement on the post-test.

The analysis of variance has indicated a significant effect of teacher gender but does not give the direction of the difference i.e. whether pupils of male teachers or of female teachers achieved higher test scores. In order to investigate further the effect of teacher gender on test scores of the pupils a t-test was performed between male and female teachers' pupil test scores for each age group rather than for each achievement band which was presented above. The results are presented in table 6.8

TABLE 6.8 SUMMARY OF THE SIGNIFICANT T-VALUES COMPARING PUPIL PERFORMANCE FROM MALE TEACHERS CLASSES WITH PUPIL PERFORMANCE FROM FEMALE TEACHER CLASSES ON TOTAL SCORES AND ON SUB-SCORES IN TEST A AND TEST B

		2nd Junior	4th Junior	2nd Secondary
Test A				
	Number	0.023 M *		0.000 M
	Reasoning	0.000 M		
	Space	0.000 M		
	Measurement	0.000 M		
	Arith. Laws	0.000 M		
	TOTAL SCORES	0.000 M		0.000 M
Test B				
	Number	0.000 M	0.012 F	
	Reasoning	0.000 M	0.010 F	
	Space	0.000 M	0.000 F	0.000 M
	Measurement	0.010 M	0.030 F	0.030 M
	Arith. Laws		0.010 F	
	TOTAL SCORES	0.000 M	0.000 F	

* *Where M denotes a male teacher has higher pupil mean scores*
F denotes a female teacher has higher pupil mean scores.

At the second year junior level pupils of male teachers had significantly higher test scores than pupils of female teachers both at the beginning of the study and towards the end of the academic year i.e. the superiority of the pupils remained throughout the study. From the details of the sample in chapter 5 it is noted that one male teacher is from a rural school with no female equivalent and the results might be influenced by the difference in school catchment areas. This possibility is investigated later in this chapter when achievement in mathematics is compared between each class.

From table 6.8 , at the fourth year level, pupils of female teachers were not superior in any section of the pre-test but superiority appeared in all sub-sections of the post-test. There was no differentiation of pupil achievement by teacher gender at the start of the year, but pupils with a female teacher achieved higher test scores towards the end of the year. If catchment area alone was the source of influence on pupil achievement, then as with the second year pupils, one would expect the gender difference to occur on the pre-test as well as on the post-test. The possibility, therefore, must exist that classroom factors contribute towards the cause of achievement differences in mathematics. Furthermore from the evidence above, where superior achievement in male classes is superior at the 2nd year junior level but in female classes at the 4th year junior level, it appears that teacher gender may interact with pupil age to have a differential effect on pupil achievement. If classroom factors do influence pupil achievement, then it is reasonable to expect that different achievement levels of girls and boys are influenced by similar classroom factors.

The results discussed so far relate to total test scores only. Research evidence has suggested that gender differences appear in certain elements of mathematics only e.g. that girls are superior in number and calculation and boys in spatial tasks. It may be that male teachers are themselves superior in some aspects of mathematics while female teachers are superior in others. If this is so then, from the research evidence cited in chapter 4, teacher attitudes and confidence will affect pupil achievement and pupils with a male or female teacher would be superior at the time when the relevant aspects are emphasised in the school curriculum. From the above results, however, the superior performance at both the second and fourth year junior levels is evident in all of the test categories. From table 6.8 , pupils of male and female secondary teachers were significantly different in performance on test A in one sub-section of the test only viz. Number, in favour of male teachers. By test B, two different sub-sections reached significance, Space and Measurement in favour of male teachers. Again, this is unlikely to be a catchment area influence, and the possibility must exist of the influence of classroom factors in fostering the superior performance of pupils in certain categories of mathematics.

In test A the category with superior performance in male classes was Number, a category associated with superior performance by females but the test was at the beginning of the year and it is likely that the previous year's teacher had been the main influence on achievement. In test B, however, after the pupils had been under the influence of the male teacher for two terms, the categories showing superior performance was Space and Measurement. It is interesting that these are categories which have been reported to result in superior performance of males and therefore supports the argument that teachers' confidence in certain aspects of mathematics has an influence on pupil achievement. However, as the effect of teacher gender was not limited to certain mathematical categories at the primary level, it appears that the influence of the teachers' confidence is greatest at the secondary level. If the effect of teacher confidence had begun in the primary school and had a cumulative effect until it became manifest at the secondary level, as hypothesised in the present study, then one would expect the data to produce strong superiority of achievement in number and arithmetic of pupils, and girls in particular, taught by female teachers in the secondary school. This is not the case, however, and therefore the influence of the interaction of teacher gender with teacher confidence appears to have effect only at the secondary age level.

Given that it is likely that teacher gender has some effect on pupil performance the question arises as to whether pupil gender also has effect on performance in mathematics. From table 6.7 , no differences in pupil gender appeared at the beginning of the study in the pre-test. At the end of the study gender differences in the post-test appeared in the Measurement sub-section only for second year juniors and secondary age pupils but not for fourth year juniors. For these fourth year juniors, however, an interaction effect of pupil and teacher gender reached significance. From these results then it appears that boys and girls achieve different levels in Measurement at the second year junior and second year secondary age level only. These are the ages at which pupils of male teachers generally attained higher achievement levels, although an interaction between teacher and pupil gender did not reach significance. The fourth year age produced significant interaction effects between teacher and pupil gender in Measurement, with pupils of female teachers achieving higher scores but the sex of the pupils who had higher achievement levels cannot be determined from the analysis so far presented. To investigate the performance of boys and girls in each mathematics category of the Bristol Achievement Test, scores are compared with the rank order of the sub-test in terms of ease/difficulty. The rank and means for each age level are presented in table 6.9

TABLE 6.9 TABLES SHOWING THE RANK ORDER OF SUB-TESTS FOR EASE/DIFFICULTY AND THE MEAN SCORES OF BOYS AND GIRLS AT EACH AGE LEVEL

*b denotes a significant higher mean score for boys
*g denotes a significant higher mean score for girls

2nd YEAR JUNIORS

TEST A	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	15.8	15.7
Reasoning	3	6.9	6.7
Space	4	5.6	6.0
Measurement	5	3.4	3.7
Arith. Laws	2	8.9	9.2
Total Means	40.9	40.5	41.4

TEST B	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	16.7	17.3
Reasoning	3	8.9	9.7
Space	4	7.8	8.6
Measurement	5	5.0	6.0 *b
Arith. Laws	2	9.6	10.0
Total Means	49.85	48.1	51.6

4th YEAR JUNIORS

TEST A	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	14.4	15.4
Reasoning	2	9.9	9.5
Space	3	7.4	7.6
Measurement	4	4.4	4.0
Arith. Laws	5	2.6	2.9
Total Means	39.1	38.7	39.4

TEST B	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	15.0	14.1
Reasoning	2	11.5	10.4
Space	3	7.6	7.4
Measurement	4	5.7	6.0
Arith. Laws	5	2.9	3.1
Total Means	41.83	42.7	41.0

2nd YEAR SECONDARY

TEST A	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	8.8	8.6
Reasoning	2	7.0	6.6
Space	3	3.0	3.3
Measurement	5	1.0	0.9
Arith. Laws	4	2.6	2.8
Total Means	22.27	22.3	22.2

TEST B	RANK based on all pupil scores	Girls' Mean score	Boys' Mean score
Number	1	9.4	10.8
Reasoning	2	5.9	6.0
Space	3	3.1	3.7
Measurement	5	1.2	1.8 *b
Arith. Laws	4	2.4	2.5
Total Means	23.57	22.0	24.7

From table 6.9 , the superiority of achievement in Measurement was due to the higher mean score of boys. Measurement was ranked as the most difficult section of all. Whether this difficulty was demonstrated by pupils making errors or by pupils omitting questions can only be determined by a detailed investigation of pupil responses to the test items and results of this investigation are presented in section 6.3. Researchers have argued that girls are more likely to omit a question if they are unsure of the answer because of a 'fear of failure' whereas boys are more likely to attempt a question rather than omit it altogether. If this is true, then the section on Measurement, which was ranked as the most difficult sub-section of the test, may have led to less girls than boys attempting the questions thus leading to a higher mean score by boys.

No significant differences appeared at the fourth year junior level where the section on Measurement was ranked 4th out of 5 for difficulty, but at the secondary level, again, the Measurement was ranked as the most difficult section and led to significantly higher scores by boys. These findings appear to be opposite to those of the infant test where girls were superior on the difficult items. One reason for this may be the method of presentation of the test. The infant pupils were tested on a one-to-one basis with the intention of reducing anxiety levels, whereas the Bristol test was presented to the whole class and required written responses. It is possible that anxiety in this test situation led to girls omitting more questions than they might in a different setting. A further possible explanation is that infant ease/difficulty was related to language factors rather than a difficulty in mathematical concepts. The absence of pupil gender differences in the fourth year may be related to the content of the section on Measurement, remembering that the section was not, this time, ranked the most difficult. Further investigation of individual items within each sub-section might help to explain the significant differences found above. This investigation will be in the form of an analysis of errors and the results presented later in this chapter.

Significant differences in the influence of teacher gender have resulted while inconsistent differences in pupil gender on performance have been found. It may be that differences that exist relate to large differences within one or two classes rather than to general differences within all of the classes and therefore the t-test was performed to compare boys' and girls' test scores for each class in the study.

A summary of the results of the t-tests on second year junior teachers is presented in table 6.10

TABLE 6.10 TABLE SHOWING THE SIGNIFICANT T-VALUES COMPARING GIRLS AND BOYS PERFORMANCE ON THE BRISTOL MATHEMATICS ACHIEVEMENT TEST FOR EACH TEACHER AT THE 2nd YEAR JUNIOR LEVEL

	TEACHER IDENTITY							
	10	12	13	15	17	18	19	20
Test A								
Number	NS	NS	NS	0.018 b	NS	0.046 g	NS	NS
Reasoning	NS	NS	NS	NS	NS	0.027 g	NS	NS
Space	NS	NS	NS	NS	NS	NS	NS	NS
Measurement	NS	NS	NS	NS	NS	NS	NS	NS
Arith. Laws	NS	NS	NS	NS	NS	0.005 g	NS	NS
TOTAL	NS	NS	NS	NS	NS	0.005 g	NS	NS
Test B								
Number	NS	NS	NS	NS	NS	NS	NS	NS
Reasoning	NS	NS	NS	NS	NS	0.053 g	NS	NS
Space	NS	NS	NS	NS	NS	NS	NS	NS
Measurement	NS	NS	NS	0.036 b	NS	NS	NS	0.044 b
Arith. Laws	NS	NS	NS	NS	NS	NS	NS	NS
TOTAL	NS	NS	NS	NS	NS	NS	NS	NS

Where g denotes a higher mean of girls
b denotes a higher mean of boys

From table 6.10 most gender differences in performance in mathematics favour girls but are restricted to one particular teacher, teacher 18. Teacher 18 is the only second year junior class from a rural school. The teacher is male, and the test scores of the class were generally higher than the other classes. These high scores would explain the presence of teacher gender differences listed in table 6.7 . The class was one described as 'traditional' in a closed classroom and using a method of class teaching followed by set examples for individual working. It is interesting to note that the superiority of girls was in the areas generally considered to favour girls - Number, Reasoning, and Arithmetic laws - but not in the areas generally considered to favour boys - Space and Measurement. The superiority of girls does not appear to the same extent in the post-test, reaching significance only in the section on Reasoning, although the test total score of the class as a whole were still higher than other classes thus effecting the appearance of teacher gender differences already described. As the differences found were limited on the whole to the pre-test, the teacher's influence on the pupils would have been minimal so early in the term and therefore one cannot conclude that the teacher in the study contributed to the cause of the differential achievement levels of the pupils.

It might be argued from the evidence so far presented, that gender differences are specific to certain classes only, the characteristics of which cannot be defined from the results presented so far in this study. As the superiority of girls was limited to test A, when the 'new' teacher had only limited time to influence the pupils, the pupils' previous experience must be considered the most likely influence. It is interesting to note, however, that the superiority of girls disappeared by the time test B was administered, apart from the section on Reasoning. This disappearance of any difference between the scores of boys and girls could be due to two possible factors; either (1) the treatment and behaviour of pupils in the male teacher's classroom, or (2) a developmental factor whereby boys, at some time in second year juniors, catch up with the girls. The first possibility is investigated in chapter 7 in the observation study. For the second possibility to be true, it would be necessary to explain a 'sudden' dramatic development of boys' mathematics achievement. A further examination of the class in question indicated that the majority of children had high scores generally in mathematics, and also had few language learning difficulties, possibly due to influences associated with the catchment area of the school (e.g. levels of parental support).. Thus the significance of language may again be in evidence here as with the infant test. If language is the main factor in level of performance on mathematics tests, then in a class where language development is early, the disappearance of girls' superiority, if it exists at all, would be earlier than in other classes where language development is late. If boys show superiority at a later point in time, then other influencing factors such as spatial experience, attitudes and confidence may play a substantial role. To test this theory, an investigation into the attitudes, confidence and spatial experience which might be present in the primary school was required and the results are presented in chapter 8.

Returning to the question of gender differences in test performance, if development of language skills is a main factor for the appearance of gender differences in mathematics performance, then one would expect few gender differences to appear at the fourth year junior age when boys have less language difficulties than at earlier ages. A summary of the t-tests on fourth year junior teachers is presented in table 6.11

From table 6.11 gender differences appear in two classes on the pre-test. Teacher 26, a male teacher, favours boys in Number and Arithmetic laws but the differences disappear by the post-test and so causal factors relating to the superiority of boys would have been prior to entry to the class and cannot be determined by the present study. However it should be noted that the two categories of Number and Arithmetic Laws are those featuring lesser amounts of written language, that is those categories which previous researchers have found to favour girls in terms of level of performance. It may be that the previous class teacher was female who influenced the performance of pupils by displaying a confidence in these categories only.

TABLE 6.11 TABLE SHOWING THE SIGNIFICANT T-VALUES COMPARING GIRLS' AND BOYS' PERFORMANCE ON THE BRISTOL MATHEMATICS ACHIEVEMENT TEST FOR EACH TEACHER AT THE 4th YEAR JUNIOR LEVEL

TEACHER IDENTITY

	22	23	24	26	27	28	29	30
Test A								
Number	NS	NS	NS	0.002 b	NS	NS	NS	NS
Reasoning	NS	NS	NS	NS	NS	NS	0.018 g	NS
Space	NS	NS	NS	NS	NS	NS	NS	NS
Measurement	NS	NS	NS	NS	NS	NS	0.003 g	NS
Arith. Laws	NS	NS	NS	0.016 b	NS	NS	NS	NS
TOTAL	NS	NS	NS	NS	NS	NS	NS	NS
Test B								
Number	NS	NS	NS	NS	NS	NS	NS	NS
Reasoning	NS	NS	NS	NS	NS	NS	0.001 g	NS
Space	NS	NS	NS	NS	NS	NS	0.009 g	NS
Measurement	NS	NS	NS	NS	NS	NS	NS	NS
Arith. Laws	NS	NS	NS	NS	NS	NS	NS	NS
TOTAL	NS	NS	NS	NS	NS	NS	0.006 g	NS

Where g denotes a higher mean of girls
b denotes a higher mean of boys

Results pertaining to a male teacher, teacher 29 indicates a superiority of girls in Reasoning and Measurement at the beginning of the academic year, while achieving a better performance than boys in Reasoning again, Space and total score on the post-test. If the suggestion presented earlier that achievement in mathematics is related to achievement in reading skills is accepted, then it might be expected that this class should show later development of language skills such that girls were still superior on the mathematics tests. The teacher's assessment of language skills in the class appeared to suggest that language skills were not so developed in boys as in girls. The above explanation therefore received some support from this data. From this evidence, one might conclude that superiority of one pupil gender over another in performance in mathematics occurred in classes of male teachers only, but it has also been pointed out that most of the differences found in achievement were in the pre-test and not the post-test. It is possible that the presence of the researcher in the schools may have resulted in the teacher being more aware of gender as an influencing factor within the classroom and therefore behaved and treated pupils differently than if they had not been made aware. Even if this was true, some significant differences were still found on the post-test and therefore one can say that presence of gender differences in performance in mathematics seems to be limited to specific classes rather than to be a global occurrence, and furthermore appears to be related to development of language skills.

A summary of the t-test results comparing boys' and girls' performance in mathematics for second year secondary age teachers is presented in table 6.12

TABLE 6.12 TABLE SHOWING THE SIGNIFICANT T-VALUES COMPARING GIRLS AND BOYS PERFORMANCE ON THE BRISTOL MATHEMATICS ACHIEVEMENT TEST FOR EACH TEACHER AT THE 2nd YEAR SECONDARY LEVEL

TEACHER IDENTITY

	31	32	33	34	35	36	37	38	39	40
Test A										
Number	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Reasoning	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Space	NS	NS	NS	NS	NS	NS	NS	NS	NS	0,002 g
Measure	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Arith	NS	NS	NS	NS	NS	NS	NS	NS	0,004 b	NS
TOTAL	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Test B										
Number	NS	NS	0,005 b	NS	NS	NS	NS	NS	NS	NS
Reasoning	NS	0,054 b	NS	NS	0,001 g	NS	NS	NS	NS	NS
Space	NS	NS	NS	NS	NS	0,036 g	NS	NS	NS	NS
Measure	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Arith	NS	NS	NS	0,036 b	NS	NS	NS	NS	NS	NS
TOTAL	NS	NS	0,005 b	NS	NS	NS	NS	NS	NS	NS

Where g denotes a higher mean of girls
b denotes a higher mean of boys

From table 6.12, only two gender differences occurred in the pre-test (test A) and these could have occurred as a result of sampling error (5% of analyses may be expected to yield significant differences by chance). In the post-test, six gender differences occurred, mostly in different sub-sections of the test, with one on total scores. Five of the significant differences were with pupils of female teachers, only one concerning pupils of a male teacher. This might suggest, then, that at the secondary age, pupils with a female teacher receive differential treatment according to pupil gender, or that previous experience of the pupils has led to an accumulation of the effects of primary school influences which becomes manifest at the secondary age level. However the inconsistency of results across the different categories within the test fails to provide conclusive evidence for either argument.

6.26 SUMMARY OF THE JUNIOR AND SECONDARY AGE TESTING

Teacher assessments of pupil achievement correlated well with pupil scores on the Bristol Achievement Test despite an initial declaration by some teachers that they were unable to provide true assessments at such an early date in the school year.

Post-test scores correlated highly with pre-test scores of the pupils and provides some support for the Pygmalian effect of teachers teaching according to their perceptions of pupils' ability. Even so, further investigation is necessary into the differential treatment of the sexes by the teacher to confirm the Pygmalian effect.

No overall pupil gender differences were found in the pre- and post-tests of the junior and secondary age pupils, such differences being found only in one or two classes when analysed separately. Thus the presence of gender differences seems to be limited to specific instances and is not the general case, thus lending no support to the biological arguments which, it has been suggested by researchers, are the main causal factors for differential attainment.

Teacher gender appeared to have some influence on pupil performance in mathematics tests but other classroom characteristics are likely to be involved too, particularly in relation to the age of the pupils, and confidence of the teacher. Significant pupil gender effects occurred in favour of boys in Measurement at the second year junior and the secondary age. This section on Measurement was ranked as the most difficult and the theory was suggested that the differences were due to girls omitting responses rather than making errors because of a 'fear of failure' as suggested by Dweck and reported in the research review in chapter 4. The trend here is in the opposite direction to those of the infant study where girls performed better than boys on difficult items. However, the rating of ease/difficulty of the infant test items appeared to be related to language associated problems wheres the Bristol Achievement Test difficulty may be related more to mathematical concepts than to language development.

The theory was presented that development of confidence and attitudes, and experience of spatial skills which are needed for high performance in mathematics tests are more positive in boys than girls at all age levels. At the primary age the late development of language skills in boys distorts test results leading to an under-estimation of boys' achievement and to subsequent extra attention by the teacher to improve the performance of boys. Some evidence supporting this theory was presented but the findings were not conclusive.

There remains the question of whether girls' and boys' differential performance in mathematics is not only in different mathematical concept areas, as discussed above, but also on individual items within the test and in the types of errors made. The hypothesis that girls make more conceptual errors which impedes their progress in mathematics whereas boys make more computational errors which does not impede their progress in mathematics is investigated in the following section. The investigation involves the study of errors in the Bristol test and will include study of the influence of language in test performance of girls and boys.

6.3 The study on the Analysis of errors

6.31 ESTABLISHMENT OF ERROR 'TYPES'

According to the hypothesis described in 5.12 girls will make more conceptual errors which impedes progress in mathematics while boys will make computational blunders which doesn't impede progress in mathematics. In order to test this hypothesis, a classification of the 'types' of errors which occur was established.

The six TARGET pupils, one boy and one girl of high, medium and low achievement level, from each class of 2nd and 4th year junior classes and 2nd year secondary classes were used for the study on errors. Using test 'A' responses each item with an incorrect response was classified according to the following criteria:

1. Language problem including failure to understand the question.
2. Omitted response.
3. Inaccurate computation - a blunder.

4. Incomplete computation - further steps in the arithmetic were necessary.

5. Recording/graphs/tables problem.

6. Effect of past experience - the child appears to be locked into a perceptual set, for example grouping in 5s or 10s when required to group in 6s or 8s.

7. Place value problem or reverse of digits - evidence from the response of failure to 'carry' or 'borrow' or failing to know the value of digits in the 'tens' column etc.

8. Inappropriate computation - wrong operation. The pupil has, for example, added instead of subtracted.

9. Spatial problem - embedded figures problem, failure to recognise relationships of different sized areas of a whole.

10. Measuring unit terminology problems - the pupil has used the wrong unit or used it incorrectly in computation.

The first items in the 2nd and 4th year junior tests could not be classified under the above headings. The pupils were required to say which 'number-domino' was the wrong way round in a row of dominoes. For these items only the errors are described as;

1. Chose the domino next door to the one requiring turning.
2. Multi-answers or no reason detectable.
3. Omitted response.

6.32 RESULTS OF THE ERROR ANALYSIS

Results of the analysis of the domino items are presented in table 6.13 in the form of percentages of girls and boys in each error category.

TABLE 6.13 TABLE SHOWING THE PERCENTAGE OF GIRLS AND BOYS IN EACH ERROR TYPE ON THE BRISTOL TEST DOMINO QUESTION.

DOMINO QUESTION

	CORRECT		NEXT DOOR		MULTI		OMIT	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
2nd Yr Jnr	80.0	81.3	4.6	7.5	11.2	8.7	4.2	2.5
4th Yr Jnr	84.7	85.0	9.3	6.0	4.3	6.0	1.7	3.0

The percentage of girls obtaining a correct response to the *domino* question was similar to the percentage of boys obtaining a correct response at both the second year junior and the fourth year junior age levels, all percentages being high.

Comparing second year junior boys and girls over the three types of error, girls responded equally with the 'multi-answer' type of error and the 'next-door domino' answer, whereas boys featured highly only in the 'multi-answers'. The 'next-door' classification is essentially a blunder rather than a conceptual error as the pupil was aware of the mis-match of dominoes but chose the wrong one to change around. Of this blunder type of error 7.5% of girls compared to 4.6% of boys responded in this way.

A multi-response error suggests a misconception of what the question requires and could be an error associated with language difficulty. From table 6.19, more boys than girls gave multi-responses (11.2% compared to 8.7%). Thus, based upon this question, at the second year junior level girls are prone to blunders and boys to language associated errors which is opposite to the hypothesis of 5.12 that girls will make more conceptual errors than boys thus impeding progress in mathematics.

At the fourth year junior level the findings are reversed - 9.3% of boys made 'next-door' blunders compared to 6% of girls, and 6% of girls gave multi-responses compared to 4.3% of boys. If multi-responses were a result of language difficulties of boys at the second year junior age, reversal of the type of errors made by girls compared to boys in the fourth year junior results suggests that not only are these language problems overcome by boys, but some factors other than language are taking effect in favour of boys some time between the second and fourth year junior ages.

Some researchers, e.g. Dweck and Bush (1976), suggested that girls are more likely than boys to omit a question as they 'fear failure' whereas boys are 'risk-takers' and will guess if they don't know an answer. From table 6.19, at the second junior level, more boys than girls omitted a question (4.2% compared to 2.5%), and so no support for Dweck's theory is provided. At the same time however, in this particular case, one cannot deduce that girls of this age are more risk-takers than boys on the basis of boys' higher frequency of omitted *responses, as pupil* responses indicate that most omitted responses were towards the end of the section of the test. It is likely that boys, for some reason such as difficulty in understanding language, or less concentration, were slower to work through the test. At the fourth year junior level, less pupils overall omitted a question, but the figures are slightly higher in the case of girls than of boys (3% compared to 1.7%). This higher incidence of omitted responses from girls might suggest that Dweck's 'fear of failure' is beginning to take effect by the fourth year. Certainly, this complete cross-over of the types of errors made by girls and boys suggests that some influencing factors take effect sometime between the second and fourth year junior ages. Before attempting to interpret the effect, further investigation of the other test items is necessary to see if the above finding is supported, particularly in the section on Measurement which was ranked as the most difficult section of the test for both second year junior and secondary age pupils.

Number.

The percentage of girls' and boys' errors across error 'types' for the sub-section NUMBER is presented in table 6.14

TABLE 6.14 THE PERCENTAGE OF GIRLS' AND BOYS' ERRORS ACCORDING TO ERROR TYPE IN 'NUMBER'.

		2Jnr	4Jnr	Sec
LANGUAGE	Girls	38.3	35.7	33.3
	Boys	17.5	18.2	26.4
OMIT	Girls	37.0	35.7	27.5
	Boys	63.5	18.2	17.0
BLUNDER	Girls	13.6	28.6	29.4
	Boys	12.7	63.6	49.0
INCOMPLETE	Girls	3.7	0	0
	Boys	1.6	0	0
RECORD	Girls	0	0	0
	Boys	0.8	0	0
PAST EXP	Girls	2.5	0	0
	Boys	0.8	0	0
PLACE VAL	Girls	3.7	0	9.8
	Boys	1.6	0	7.5
WRONG OP	Girls	1.2	0	0
	Boys	1.6	0	0

In Number at the second year junior age 38.3% of girls' errors were associated with language problems and 37% omitted responses. Blunders accounted for 13.6% of errors, while conceptual errors such as place value and wrong operation accounted for 7.4%. Of boys' errors, 62.5% were due to omitted responses, 17.5% to language difficulties, 12.7% to blunders and 4% to conceptual errors. Thus at the second year junior level in Number girls made more language errors and conceptual errors than boys who mostly omitted responses. The omitted responses of boys might, however, be due to language difficulties resulting in boys being slower or choosing not to respond, or it might be that boys' attention to the task is not as great as girls' and leads to less work being done, either due to lack of motivation or to time spent on bad behaviour. The present study's observation within the classroom and investigation of attitudes will help in the interpretation of the above findings.

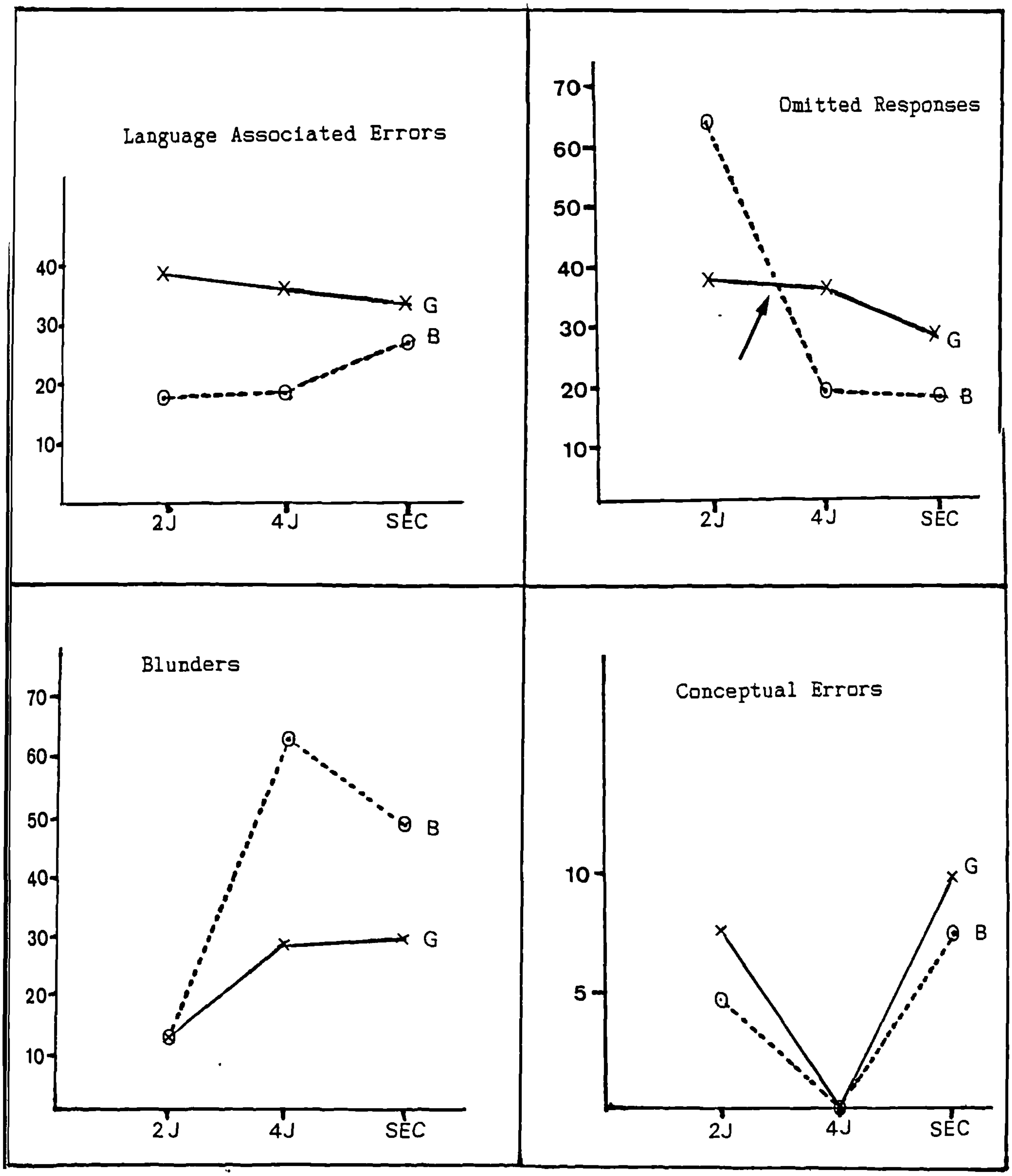
At the fourth year junior age, girls made language associated errors and omitted responses similarly to the second year junior age but girls also made blunders rather than conceptual errors. Boys, at the fourth year, omitted less questions but had a high blunder rate. Thus boys were, by the fourth year junior age, attempting to answer the questions rather than leaving them out but made silly mistakes in the process. Language difficulties didn't seem to be evident at this age for boys and so the reason for the occurrence of blunders requires further investigation. Boys may be rushing to get the work done, especially if they have been wasting time instead of working, but this is, so far, pure conjecture and so information from the observation study will be important to aid interpretation of the above findings.

At the secondary school age results similar to those of the fourth year junior age were found which suggests that the main difference in boys' and girls' errors occurs sometime between the second year and fourth year junior age level in the mathematical area of Number. Figure 6.1 presents a graphical representation of error types in Number for both boys and girls. The higher occurrence of language errors by girls than by boys at all age levels in Number seems contrary to what would be expected from the theory presented earlier, of boys being behind girls at primary

Figure 6.1 NUMBER

Graphical Representation of the Distribution of Errors for each Error Type.

Percentage of Total Errors



level mathematics due to language problems and then overtaking girls as language ceases to be so vastly different for girls compared to boys. However, if the 'omit' errors are due to language problems rather than a speed of working factor, then adding the figures together from table 6.14 girls would have 75.3% language associated errors and boys would have 81% language associated errors. Thus the theory presented earlier may still hold true. The differences which occur between the second and fourth year junior errors indicate the need to look at the observation study in an attempt to identify the influencing factor for this change. The question remains as to whether this change is limited to Number or includes other mathematical areas too.

Reasoning.

The percentages of girls and boys in each error category for the sub-section REASONING are presented in table 6.15

TABLE 6.15 THE PERCENTAGE OF GIRLS' AND BOYS' ERRORS ACCORDING TO ERROR 'TYPE' IN 'REASONING'

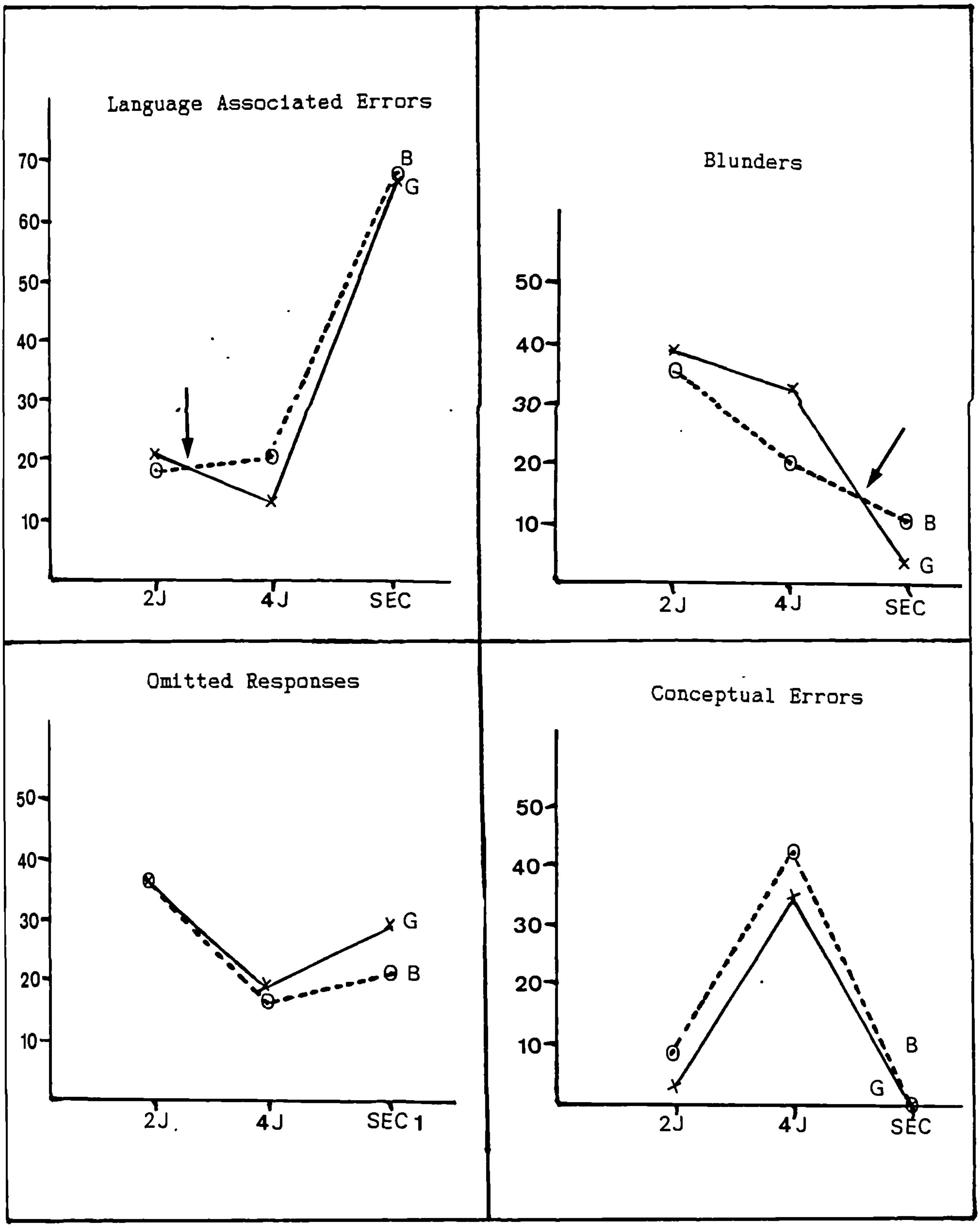
		2nd Jnr	4th Jnr	Sec
LANGUAGE	Girls	21.3	13.0	66.7
	Boys	19.0	20.4	67.6
OMIT	Girls	36.0	19.6	29.6
	Boys	36.2	16.7	21.6
BLUNDER	Girls	38.9	32.6	3.7
	Boys	36.2	20.4	10.8
SPATIAL	Girls	3.7	34.8	0
	Boys	8.6	42.6	0

In the section on Reasoning, four error types occurred - language difficulties, omitted response, blunder and spatial error. From table 6.15 at the second year junior level, gender differences were not

Figure 6.2 REASONING

A Graphical Representation of the Distribution of Errors for each Error Type.

Percentage of Total Errors



evident, errors being spread over blunders, omitted responses, and language. Very few spatial errors occurred overall but the percentage of errors in this category was higher for boys (8.6%) than for girls (3.7%).

At the fourth year junior level, many more spatial errors occurred, and again, more by boys than by girls (42.6% compared to 34.8%). These findings are consistent with those of Weiner (1980) and Lips and Colwill (1978) who found that girls were equal or superior to boys in spatial skills at the primary age until a change to superiority of boys at about the age of 14 years. From table 6.15, girls made more blunders than boys, while boys had more language associated errors. At the secondary age most errors were concerned with language difficulties for both girls and boys. The high incidence of errors associated with understanding of what the question was asking suggests that mathematical language in earlier years has not been grasped successfully by the pupils and continued to be a barrier to success in mathematics tests. Linked closely to knowing what a question asks is the ability to apply mathematical skills in the relevant way. The present study's method of classifying errors has relied on conjecture and the need for interviewing pupils is clearly underlined to be able to distinguish between comprehension of a test item and the ability to apply mathematical skills.

Other errors at the secondary age show that more girls than boys omitted a response while more boys than girls made blunders. This pattern of errors is consistent with Dweck's theory of 'fear of failure' of girls and also the hypothesis of 5.12 that boys make blunders which don't impede progress in mathematics.

For Reasoning then, a change regarding types of errors of boys compared to girls seems to occur sometime between the second year junior and fourth year junior age for language errors, and fourth year junior and second year secondary for blunders (see figure 6.2). The findings are, therefore, consistent with those of Weiner (1980) and Lips and Colwill (1978), girls being superior to boys on spatial tasks until 14 years of age. The findings do not, however, support the hypothesis 5.12 that girls make conceptual errors which impedes progress while boys make more blunders which does not impede progress until the secondary age. The hypothesis however may apply only to specific mathematical areas.

Space.

TABLE 6.16 presents the percentage of girls' and boys' errors in each error 'type' for the sub-section SPACE.

TABLE 6.16 THE PERCENTAGE OF GIRLS' AND BOYS' ERRORS ACCORDING TO ERROR 'TYPE' IN 'SPACE'.

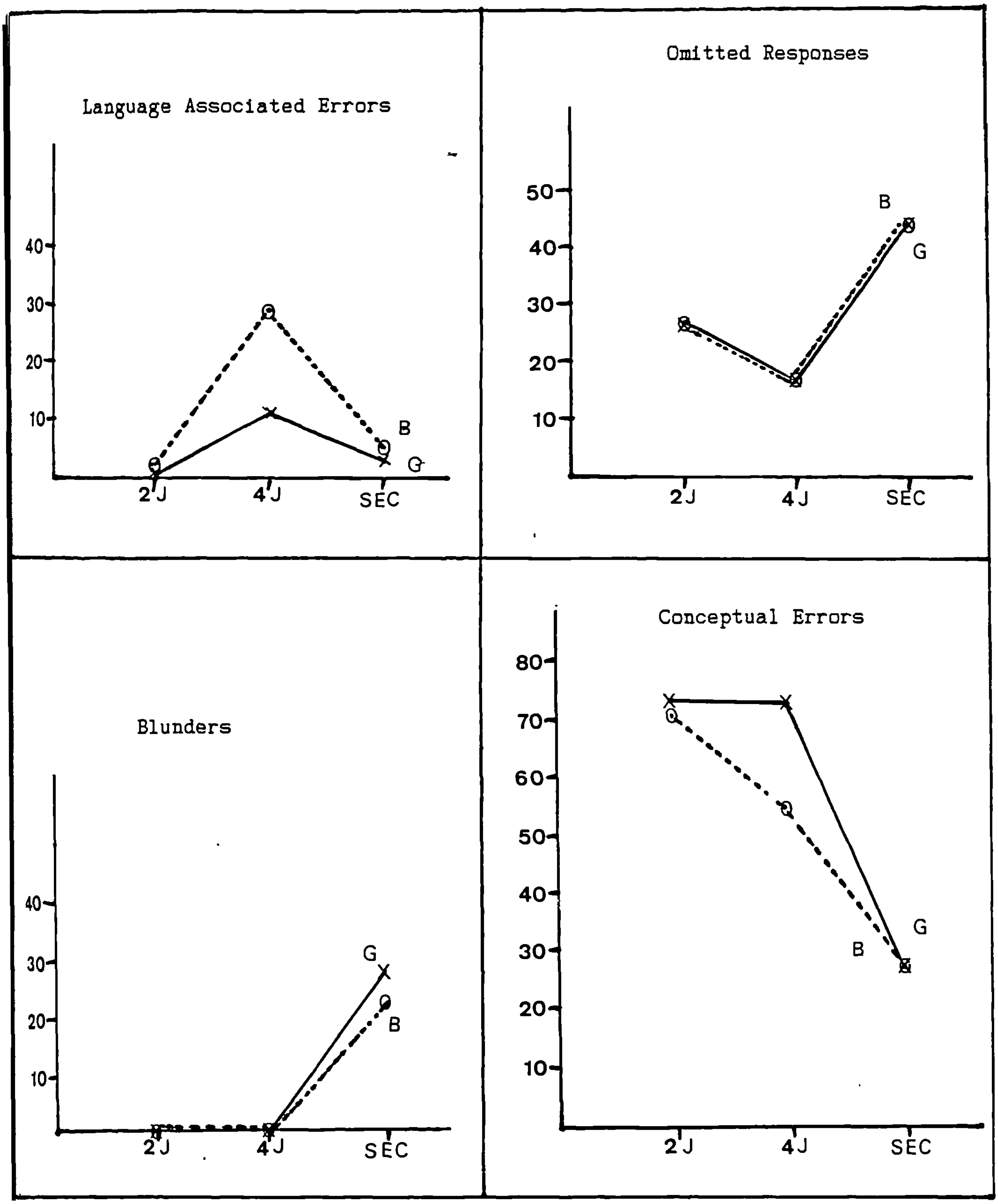
		2nd Jnr	4th Jnr	Secondary
LANGUAGE	Girls	0	10.9	2.7
	Boys	1.8	28.6	5.3
OMIT	Girls	26.7	16.4	43.2
	Boys	26.1	16.1	43.4
BLUNDER	Girls	0	0	27.0
	Boys	0	0	23.7
PAST EXPER	Girls	0	0	0
	Boys	0	0	2.6
WRONG OP.	Girls	0	0	27.0
	Boys	0	0	22.4
SPATIAL	Girls	73.3	72.7	0
	Boys	72.0	55.4	0
MEAS. UNIT	Girls	0	0	0
	Boys	0	0	2.6

In the sub-section on Space, error types include language, omitted response, blunder, past experience, and concept errors such as wrong operation, spatial, and measuring unit. At the second year junior level,

Figure 6.3 SPACE

A Graphical Representation of the Distribution of Errors for each Error Type.

Percentage of Total Errors



most errors were of the type omit or spatial. No gender differences occurred at this age level.

At the fourth year junior level more boys had language difficulties but more girls had spatial errors. At the secondary age level few differences in pupil gender were found, errors being omitted response, blunder or wrong operation for both girls and boys (see figure 6.3). The findings do not clearly support or refute the theories of Weiner or Dweck.

Measurement.

The percentages of girls' and boys' errors in each category for the sub-section 'MEASUREMENT' are presented in table 6.17

TABLE 6.17 THE PERCENTAGE OF GIRLS' AND BOYS' ERRORS ACCORDING TO ERROR 'TYPE' IN 'MEASUREMENT'.

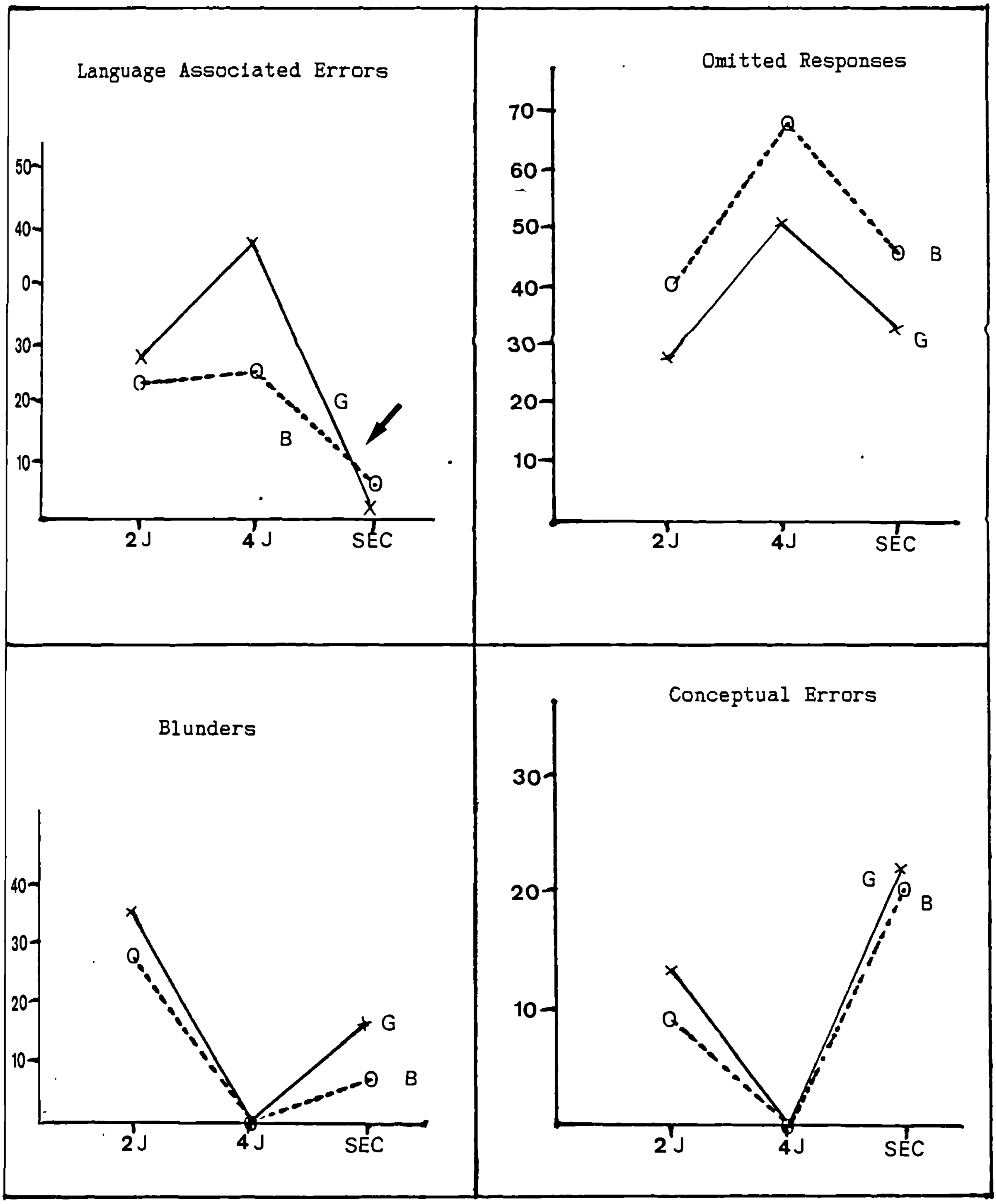
		2nd Jnr	4th Jnr	Sec
LANGUAGE	G	25.6	46.4	2.0
	B	23.3	25.0	5.9
OMIT	G	26.7	50.0	32.0
	B	39.5	67.9	45.0
BLUNDER	G	34.4	0	16.0
	B	27.9	0	7.8
RECORD	G	0	3.6	28.0
	B	0	7.1	19.6
WRONG OP	G	0	0	4.0
	B	0	0	9.8
MEAS. UNIT	G	13.3	0	18.0
	B	9.3	0	11.8

In Measurement errors include language, omit, blunder, recording problem, wrong operation, and measuring unit problem. At the second year junior level, more girls made blunders while more boys omitted questions.

Figure 6.4 MEASUREMENT

A Graphical Representation of the Distribution of Errors for each Error Type.

Percentage of Total Errors



Slightly more girls made conceptual errors. Thus the findings for second year juniors in Measurement lends some support to the hypothesis of 5.12 in that girls make conceptual errors which impedes progress. However, if this hypothesis was true, then at the fourth year juniors and above girls should be expected to fall further behind in progress and make even more conceptual errors. From table 6.17 it is clear that this is not the case. If omitted questions is associated with language errors, then adding the Omit and Language error totals gives, at the second junior age, 52.3% of language associated errors for girls and 62.8% for boys i.e. boys have more language difficulties. At the fourth year junior age girls and boys made about equal numbers of language errors. This gives some support to the language theory presented earlier in the present study, but not to Dweck's 'fear of failure' arguments since girls did not make more omissions than boys in the section on Measurement where, as discussed in section 6.2, boys performance was superior to girls.

Similarly. at secondary age, the occurrence of conceptual errors for boys and girls was approximately equal although more boys omitted questions and girls had more recording problems in this section which related to graph reading difficulties. Fewer language errors occurred, most errors being due to omitted responses or to recording problems. It seems that both girls and boys found difficulty reading the graphs and, perhaps through the shortage of time, left out many of the questions. However, more girls did attempt the questions which, if Dweck's 'fear of failure' is correct, means that, in this instance, it applied to boys rather than to girls. Alternatively, boys could also have lacked motivation or exhibited a high degree of bad behaviour which decreased their working time. The observation study should confirm the interpretation of these results. A graphical representation of the errors is presented in figure 6.4.

Arithmetic Laws.

Table 6.18 presents the percentage of girls' and boys' errors in each error category for the sub-section 'ARITHMETIC LAWS'.

TABLE 6.18 THE PERCENTAGE OF GIRLS' AND BOYS' ERRORS IN EACH ERROR CATEGORY IN 'ARITHMETIC LAWS'.

		2nd Jnr	4th Jnr	Sec
LANGUAGE	Girls	8.5	4.8	12.5
	Boys	2.3	10.3	8.9
OMIT	Girls	36.6	4.8	49.4
	Boys	29.5	10.3	55.6
BLUNDER	Girls	8.5	4.8	5.2
	Boys	11.4	0	4.4
INCOMPLETE	Girls	3.7	0	0
	Boys	5.7	0	0
PLACE VAL	Girls	3.7	0	0
	Boys	10.2	0	0
WRONG OP	Girls	39.0	85.7	7.3
	Boys	40.9	79.0	12.2
MEAS. UNIT	Girls	0	0	15.6
	Boys	0	0	18.9

In Arithmetic Laws, most errors were due to omitted responses or to use of the wrong operation. At the second year junior level, more girls omitted questions than boys did while boys' errors were equally distributed across all of the error types.

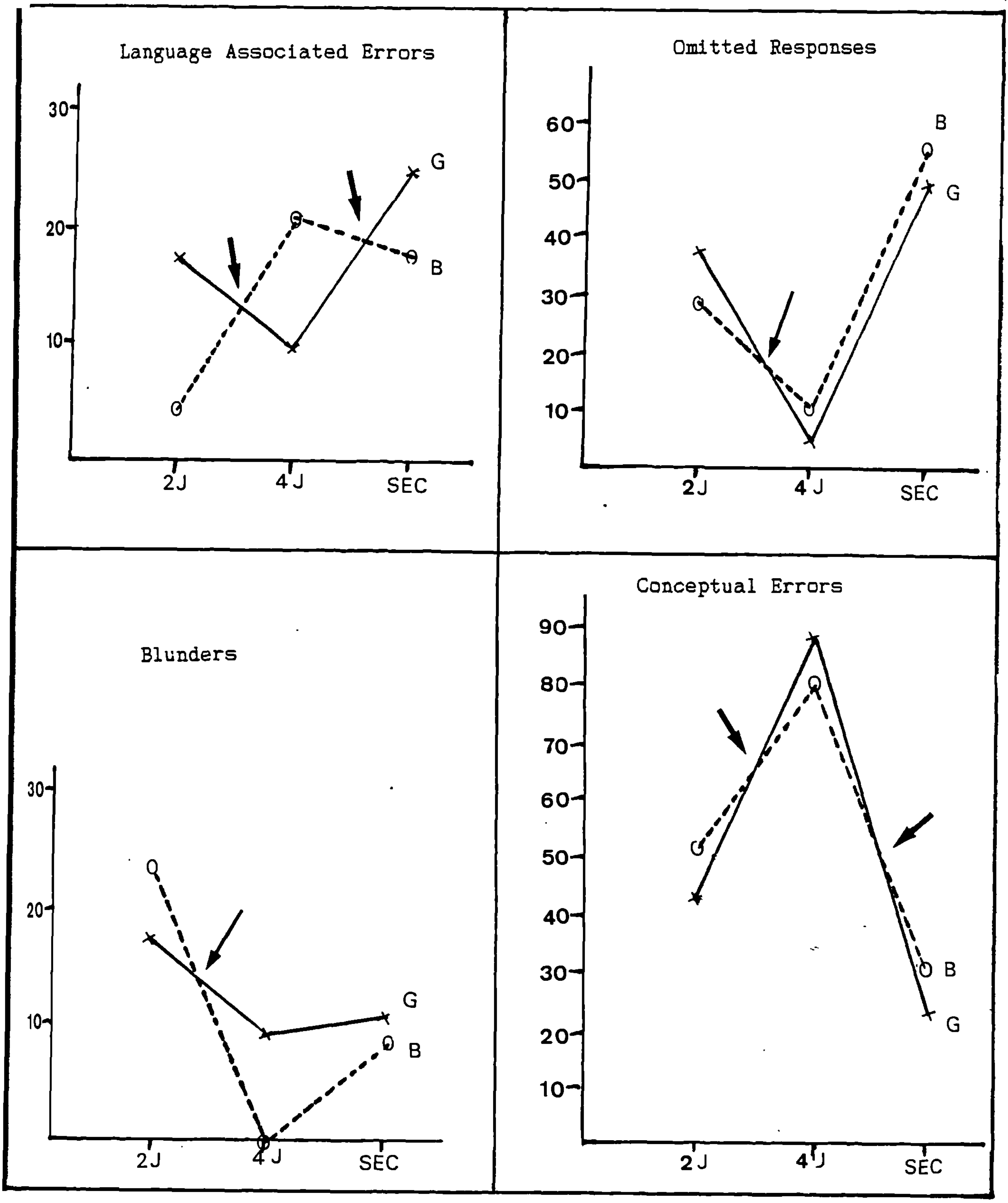
At the fourth year junior level, boys had high language and omitted response errors while girls made blunders and conceptual errors in the form of using the wrong operation i.e. girls made an attempt to answer the questions but made errors, boys either didn't attempt the questions or didn't understand what was required of them due to language problems.

At the secondary age, boys omitted responses more than girls did and also made conceptual errors (wrong operation).

Figure 6.5 ARITHMETIC

A Graphical Representation of them Distribution of Errors in each Error Type

Percentage of Total Errors



Thus the main change in differences between the pupil gender occurred between the second year junior and the 4th year junior age levels (see figure 6.5).

6.33 SUMMARY OF JUNIOR AND SECONDARY ERROR 'TYPES'.

A summary of the types of errors that occurred in each sub-section of the test at each age level is presented in table 6.19

If Dweck's 'fear of failure' hypothesis holds, then from table 6.19 at the second year junior level, only Arithmetic Laws and Space caused greater 'fear of failure' in girls than in boys; at the fourth year junior level the areas affected were Number and Reasoning; at the second year secondary level the areas affected were again Number and Reasoning. This suggests that any effect of 'fear of failure' on mathematical performance from primary age to secondary age was limited to certain mathematics areas. Similarly omitted responses of boys was limited to Number and Space at the second year junior age, Arithmetic Laws and Measurement at the fourth year junior level, and Arithmetic Laws and Measurement at the secondary age. In summary a change in mathematical areas causing a 'fear of failure' occurred sometime between the second and fourth year junior ages, but the reason for such a change cannot been determined.

TABLE 6.19 A SUMMARY OF ERROR TYPES FOUND TO BE DOMINANT FOR ONE OF THE PUPIL SEXES AT EACH AGE LEVEL WITHIN EACH AREA OF MATHEMATICS TESTED BY THE BRISTOL ACHIEVEMENT TEST.

2nd Jnr

	ARITH LAWS		NUMBER		REASONING		SPACE		MEASUREMENT	
	boys	girls	boys	girls	boys	girls	boys	girls	Boys	girls
CONCEPT	X			X				X		X
BLUNDER	X					X				X
LANGUAGE		X		X		X				X
SPATIAL					X					
OMIT		X	X					X	X	
RECORD										

4th Jnr

	ARITH LAWS		NUMBER		REASONING		SPACE		MEASUREMENT	
	boys	girls	boys	girls	boys	girls	boys	girls	Boys	girls
CONCEPT		X						X		
BLUNDER		X	X			X				
LANGUAGE	X			X	X		X			X
SPATIAL					X					
OMIT	X			X		X			X	
RECORD										

2nd Sec

	ARITH LAWS		NUMBER		REASONING		SPACE		MEASUREMENT	
	boys	girls	boys	girls	boys	girls	boys	girls	Boys	girls
CONCEPT	X							X		X
BLUNDER		X	X		X			X		X
LANGUAGE		X		X	X		X		X	
SPATIAL										
OMIT	X			X		X			X	
RECORD										X

As stated earlier in the research review, theorists have suggested that boys make more blunders and girls more conceptual errors and also more omissions. These theories were based on overall test responses rather than individual mathematical areas. In order to compare the findings with those of the present study, total errors over the whole test rather than within each concept area in relation to gender differences are presented in table 6.20

TABLE 6.20 TOTAL PERCENTAGE OF ERROR TYPES FOR THE WHOLE TEST.

	LANG		OMIT		BLUNDER		CONCEPTUAL	
	G	B	G	B	G	B	G	B
2J	18.7	12.6	28.2	38.7	19.1	17.6	29.1	28.6
4J	22.2	24.0	25.3	25.8	13.2	16.8	39.4	36.8
SEC	23.4	22.8	38.3	36.5	16.3	19.1	21.9	21.5

At the second year junior level, girls had more language and comprehension problems and made more blunders while boys omitted questions more than girls. Little gender differences existed in conceptual errors. Thus conceptual errors were not impeding girls' progress more than boys at this stage. At fourth year junior level, boys made more blunders than girls while girls made conceptual errors. At this stage therefore, that the hypothesis of 5.12 and Dweck's theory of 'fear of failure' becomes a possibility. At secondary level, girls omitted more items than boys, while boys made more blunders and 'fear of failure' could therefore exist at this secondary age. However, as can be seen from the study of error types, although total test results give support for Dweck and for the hypothesis 5.12, when mathematics areas were examined individually inconsistent results were obtained.

If concepts are taken to be the key to successful progress in mathematics, a comparison between areas of mathematics in which boys are superior to girls and girls to boys should indicate the possible problem areas for future years. The skill areas in which girls or boys made more conceptual errors than each other are presented in table 6.21.

TABLE 6.21 MATHEMATICAL AREAS IN WHICH GIRLS COMPARED TO BOYS MADE MORE CONCEPTUAL ERRORS ACROSS DIFFERENT AGE LEVELS

2ND JNR		4TH JNR		SECONDARY		TOTAL	
B	G	B	G	B	G	B	G
Arith. Reason.	Number Space Measure	Reason.	Arith. Space	Arith.	Space Measure	Arith. Reason.	Arith. Number Space Measure

From table 6.21, the only consistently difficult area was Space for girls. This result applied across all of the age groups. If there is a build-up of the effects of conceptual errors in mathematical areas and if this impedes progress at some later stage in schooling then it follows from table 6.21 that after the second year of secondary school one would expect girls to be superior to boys in Reasoning and boys to be superior to girls in Number, Space and Measurement. These were, in fact, the areas found to be superior for each of the sexes by Freedman (1985) in the Basic Numeracy Test, results also supported by the APU findings. Arithmetic Laws, in which Freedman found girls to be superior does not follow this pattern.

Nevertheless, it does seem possible that the conceptual errors made by pupils at some stage throughout their schooling affects their subsequent performance at the later secondary stage. A complete understanding of this trend would require further analysis as to why these conceptual errors occurred and how they occurred. Such analysis would involve 'in depth' pupil interviews at the time of the test administration, a task beyond the resources available in the present study.

6.34 CONCLUSION

The main purpose of the analysis of errors was to test hypothesis 5.12 that girls make more conceptual errors which impedes their progress while boys make blunders which does not effect performance. Some evidence has been produced to support the hypothesis but only if it is accepted that the effect of conceptual errors builds up and becomes manifest later on at the secondary age level.

Conceptual errors were not consistent from one year to the next in individual mathematics areas or in total test errors. However, the areas in which conceptual errors did occur for boys and girls <u>at some time</u> between the ages of second year junior to second year secondary age were the same mathematics areas in which other researchers have found gender differences in test performance e.g. Freedman (1985).

The results of the analysis of errors were applied to the theory of Dweck and Bush (1976) that girls fear failure and therefore omit questions rather than guess and get them wrong, whereas boys are risk-takers and will guess an answer rather than omit a question. The findings of the error analysis were consistent with Dweck's theory at the second year junior age for two mathematics areas only - Arithmetic Laws and Space. At both the fourth year junior and second year secondary ages, the findings are consistent with Dweck's theory in the areas of Number and Reasoning. Opposite findings were obtained for Measurement and Arithmetic Laws (i.e. the girls seem to be the risk-takers from the fourth year junior age upwards). Thus Dweck's theory is not supported by the present study unless one qualifies it by hypothesising that only certain mathematical areas are affected by this phenomenon. What does seem apparent however, is that a change occurs sometime between the second and fourth year junior ages and this has an effect on mathematical performance and the types of errors which occur.

Earlier in the present study, it was argued that girls are only superior (or equal) to boys in mathematics performance during the time that language skills have not yet fully developed in boys, but that once this language barrier has been removed then other factors begin to influence performance on mathematical tests and boys become superior to girls. The present analysis of errors supports this theory only if it is assumed that omitted responses are also due to language difficulties and not to lack of motivation or to time wasting, perhaps through bad behaviour.

These conclusions leave the following questions unanswered :

1. How and why do conceptual errors occur?
2. Does teacher behaviour and pupil behaviour differ according to the area studied?
3. Do boys waste more learning time than girls do during mathematics lessons?
4. Do boys have positive attitudes towards mathematics with higher levels of motivation?

All the above issues are related to classroom behaviour and are investigated in the following chapter, where the behaviour of both pupils and teachers is described. Pupil attitude will then be examined in chapter 8.

CHAPTER 7

THE STUDY ON BEHAVIOUR WITHIN THE CLASSROOM

The review of the literature in chapter 4 presented several theories to account for the superior mathematical performance of boys by the secondary age. Many of the theories relate to the way in which pupil and teacher behaviour in the classroom may influence performance in mathematics. Some methods of teaching e.g. discovery learning, have been argued by some researchers to benefit one gender more than the other, perhaps as a result of different rates of development of girls and boys, in terms of acquiring mathematical concepts.

Other researchers, e.g. Whyte (1983), have suggested that girls' poor mathematical performance is due to a lack of confidence which is the result of a passive and low participatory type of behaviour in the classroom. In contrast, boys' high level of confidence is demonstrated by active, participatory behaviour, and by successfully demanding the teacher's time and attention.

Others have suggested that an emphasis on reading and language skills at the infant age helps boys to develop more rapidly in areas in which they are reported to have difficulty. Spatial skills however, in which girls are reported to have difficulty, are not emphasised to the same extent and there is, therefore, a bias of teaching in favour of boys.

As boys generally develop language skills later than girls, they become more accustomed to the teacher's presence while receiving extra attention for developing their language. Hence boys learn to feel at ease when interacting with the teacher. Girls, who do not need so much attention to develop language, continue to have problems in their exchanges with the teacher. The literature goes further and suggests that teachers frequently praise slow learners (boys in both language and mathematics at the primary age), and boys consequently gain a false sense of high esteem. Girls, however, suffer from a lack of confidence as a result of seeing boys receive more praise from an authoritative source such as the teacher.

In addition to the effect of teachers' presence on self-confidence, Adams and Biddle (1970) reported that pupils stopped working when the teacher left the group's presence. As the teacher paid more attention to boys than to girls because of behaviour and language problems, this led to girls spending less time working on mathematics than boys did. This latter theory does not, however, explain why the amount of time spent working on a task should have a detrimental effect specifically in mathematics and not in other curriculum areas.

Support for some of these theories was found in the study of pupil performance on tests of mathematical concepts and the results were presented in chapter 6. The theories do, however, require further evidence from the study of behaviour and treatment of pupils in the classroom. The ORACLE project's study of secondary age pupils reported that pupil style, in terms of pupil behaviour, was different according to the curriculum area being taught. The primary data, however, was not analysed for each curriculum area separately and therefore re-analysis of the data is important to the present study, particularly with respect to the relationship between pupil gender and pupil style in mathematics. The present chapter investigates the theories outlined above on the basis of the main hypotheses as described in 5.13 and 5.14

5.13 that there is a significant difference in the behaviour of pupils in mathematics when compared to other curriculum areas, especially English, and that within this variation there is a gender difference.

5.14 that boys receive more attention from the teacher, in particular more criticism as well as more praise, and that this frequency of attention is related to achievement in mathematics.

The results of this behaviour study are also compared to the findings discussed in chapter 6 on pupil gender differences in test performance and types of error which occurred. To make this possible so that the behaviour of girls and boys could be compared across different curriculum areas, the data from the ORACLE study (Galton et al,1980) was re-analysed. The results are presented in the following section.

7.1 Re-analysis of the ORACLE data.

7.11 THE INSTRUMENTS AND PROCEDURE FOR ADMINISTRATION

Developed at Leicester by Boydell (1974,1975) the Pupil Record of behaviour was initially modelled on PROSE (Personal Record of School Experience: Medley et al,1973). The record focuses on the nature and frequencies of pupil activities in the classroom, and of interaction with the teacher, peers, or others. The record consists of three sections of categories of which the first relates to pupil location and activity, for example whether a pupil was working in their usual work base, out of their work base, or mobile and walking around the room; whether the pupil was working on the task or routine matters or whether s/he was distracted from the task. The second section concerns interaction with other pupils, such as whether pupils of the same gender as the target pupil were involved, or pupils of different gender, and whether the interaction was verbal or of some other form. The final section involved interaction with the teacher, including the subject initiating the interaction and whether it was for task, routine or behavioural reasons. A full list of the variables is presented in Appendix 3. The observer was required to be as inconspicuous as possible in the classroom and to record the pupil's activity at a specific instant by ticking the relevant category. A cassette player with an earpiece to emit a signal every 25 seconds was used by the observer to indicate this 'instant'. The observer focused on one pupil for five time intervals and then moved on to another pupil. A similar procedure was followed for observing the teacher but the teacher record placed greater emphasis on the types of questions and statements used by the teacher.

In recent years there has been considerable debate about the effectiveness of different approaches for collecting information about various aspects of the classroom process (e.g. Nash,1973; Adams and Biddle,1970; Burgess,1986). Methods of classroom investigation in British schools prior to the ORACLE project in 1975 had tended to rely on questionnaires which have been shown to be unreliable for several reasons. First, people find it difficult to report objectively on themselves. In some cases responses tend to indicate what subjects feel is desirable rather than what is reality. Secondly, the wording of questionnaires is open to interpretation and may be ambiguous. In order to encourage people to complete a questionnaire the design is usually one of short statements requiring multiple-choice response. When language is cut down to a minimum in short statements it is difficult to be perfectly clear about the meaning to be conveyed and therefore two respondents may interpret the same question quite differently. With multiple-choice response items there is also a suggestion that one of the choices is the correct answer and the responder may try to judge which is the correct answer rather than which s/he feels is their own reality.

The ORACLE team noted that there have been many criticisms of observation schedules, some concerned about the failure to validate observational systems (Nuthall and Snook,1973; Rosenshine and Furst,1973) while others have argued the need for more attention to the setting and context in which the observation takes place (Rosenshine,1970; Dunkin and Biddle,1974). Other researchers, however, have supported the use of observational methods (Walker and Adelman,1976; McIntyre and MacLeod,1978). ORACLE researchers attempted to overcome criticisms about validity by using more than one instrument in the same classroom. The ORACLE study also collected descriptive accounts of the settings in which the observations took place. Delamont (1984) however has still expressed reservations concerning the use of systematic observation. The main criticisms concerned the validity of limiting the information which is to be observed in that sampling techniques omit a great amount of 'relevant' information. However, while it is accepted that use of observation instruments do limit the amount of data collected on behaviour or interactions, the categories contained in the instrument are pre-specified based on previous research results and therefore reliance is placed on the validity of the initial research study.

Reliability of observers can be achieved easily with adequate training but the question of what variables are to be observed are another matter. There are thousands of possible things one could observe but as long as those chosen are described in full the reader knows exactly what the results refer to and whether s/he sees them as correct variables to observe or not doesn't invalidate the results.

The question of whether observation schedules are really objective is difficult to determine. Even with checklists of categories there may be a certain amount of subjective recording as the observer has to interpret what s/he sees and hears e.g. the teacher saying 'John' may be said in a loud voice for the whole class to hear, meaning the whole class should be quiet, or may be related to John only. But if observers are well trained in the use of the schedule then reliability studies of two observers observing the same events should indicate if the same interpretations were made. The ORACLE study used observation in two consecutive years and found that results from the second year were almost identical to the first, indicating that the findings from the first year were reliable and not due to chance. Use of impressionistic accounts supplemented the observation data to provide a more detailed picture of the primary classroom.

Delamont (1984) suggests that the presence of an observer must have an effect on the classroom behaviour and although the observation schedule used by ORACLE included a category to record pupil attention to the observer, no details were published. The re-analysis of the data investigates this effect. A full discussion of the criticisms of systematic observation which have been outlined above has been provided by Croll (1986). In conclusion, the criticisms pointed towards systematic observation can all be answered satisfactorily, provided full details of definitions of the categories used for observation and descriptive accounts of classroom settings are presented to the reader to aid interpretation of the findings.

7.12 STATISTICS USED IN THE RE-ANALYSIS OF THE ORACLE DATA.

The ORACLE team analysed the observation data by means of iterative relocation using a Euclidean distance measure, a procedure commonly known as cluster analysis. This particular procedure is contained in the Clustan system of computer programmes (Wishart,1969). Cluster analysis attempts to sort people into groups of similar individuals so that each member of the group has more characteristics in common with the other members of that group than with members of the other groups. The use of cluster analysis in educational research was first used by Barker-Lunn (1970) who studied streaming and found two teaching styles which closely resembled the progressive/traditional types. A method of cluster analysis was also used by Bennett (1976), but uncertainties about using the technique have been voiced in recent years (e.g. Solomon and Kendall,1979; Hartigan,1977; Aitkin et al,1981). The main argument relates to how one knows what constitutes a cluster. Everitt (1977) and Aitkin have questionned the basis upon which a decision is reached that a particular cluster result would have been produced by a different sample from the same population. Aitkin (1979) has argued that it cannot be assumed that teacher styles and pupil types are distinguishable since style could be either multi-dimensional or on a continuum with formal at one end and informal at the other. Croll, however, points out that researchers can repeat the cluster analysis with different initial allocation to clusters and if the same cluster pattern emerges then the researcher can have greater confidence that the results reflect a true structure in the data.

For the ORACLE data, use of cluster analysis is preferable to scattergrams as the large amount of data makes scattergrams confusing, and discriminant function analysis (Hand,1981) is also unsuitable as it is concerned with assigning new individuals to a priori defined groups. Another frequently used technique, factor analysis, groups variables rather than individuals and assumes an explicit linear model so is, again, unsuitable although it must be accepted that all these methods may to some extent be considered complementary in the analysis of complex multi-variate data. Everitt has suggested that there is a need to look at data from several viewpoints to see if there is, in fact, a tendency to cluster. He suggests a preliminary analysis using bivariate scattergrams, principal components etc.; if none exhibit cluster structure then Everitt argues it is unlikely that clustering would be the most appropriate form of analysis (Everitt,1983). As already stated however, the large amount of data in the ORACLE project makes this preliminary analysis inappropriate. Everitt has further suggested that cluster analysis should be used as a means of suggesting further analysis on different subsets of data rather than for immediate interpretation of results.

At the beginning of the present chapter it was stated that the use of cluster analysis in the ORACLE study of primary schools (Galton et al,1980) was based on data from all curriculum areas put together in the analysis. For the present study, however, behaviour of pupils in separate curriculum areas is necessary in order to compare behaviour of boys and girls in mathematics and English. Re-analysis involved the use of cluster analysis by the computer procedure Clustan (Wishart,1969) on subsets of data by curriculum area.

The re-analysis also incorporated a t-test to determine whether or not the means of two samples are likely to have been drawn from the same population. In the re-analysis, this statistical method was employed on the data with each variable used in the ORACLE observation study to compare differences between the means of boys' and girls' frequencies of behaviour. The SPSS computer statistical package was used for the analysis. Because no prediction is presented about the direction of frequencies (i.e. that boys would have higher mean frequencies than girls or vice versa) a two-tailed test was appropriate. The main question to be answered by the t-test results is therefore whether boys or girls participate in certain behaviours more frequently.

7.13 RESULTS OF THE CLUSTER ANALYSIS OF THE ORACLE DATA

The variables used in the cluster analysis consisted of the single categories on the observation schedule which relate to pupil behaviour and interation between pupil and pupil, and pupil and teacher e.g. 'TKWK' (adult interacts with the pupil about the task work), *PIN* (pupil is in his base of work). A list of the variables is presented in Appendix 3. An analysis was performed for each of the four LEAs involved in the study, for each pupil age group and for each of the curriculum areas, (mathematics, English, and topic). The analyses performed are listed below.

1.	MATHEMATICS	8-10 year olds
2.	ENGLISH	8-10 year olds
3.	TOPIC	8-10 year olds

Junior Type Schools

4.	AGE 8-9	LEA 3
5.	AGE 8-9	LEA 4
6.	AGE 9-10	LEA 2
7.	AGE 9-10	LEA 4
8.	AGE 10-11	LEA 2
9.	AGE 10-11	LEA 4

High Schools (8-12 or 9-13)

10.	AGE 9-10	LEA 3
11.	AGE 10-11	LEA 1

In the analyses 4 to 11, where data for each curriculum area was included, each child was counted as 3 cases (one mathematics, one English and one topic) whereas in the other analyses each pupil was counted as one case only.

The clusters resulting from the analyses, defining pupil 'types', were put into the form of relative frequency of use of the pupil record categories as used in 'Inside the Primary Classroom' (Galton et al,1980,p144). The range between the highest and lowest use of each category by the pupil types was divided into four parts. The bottom quartile was a 'relative low use' category, the top quartile was a 'relative high use' category, and the two middle quartiles were an 'average use' category. By assigning values of 3 for high, 2 for medium and 1 for low frequency a correlation, as a measure of similarity, was then performed between these clusters from the re-analysis and the Attention Seekers, Intermittent Workers, Solitary Workers, and Quiet Collaborators as defined in the original ORACLE analysis.

7.13.1 PUPIL TYPES IN MATHEMATICS.

Using the data for mathematics with only 8 - 10 year old pupil data, four clusters resulted from the re-analysis. Table 7.1 presents the figures of correlation between each of these clusters with each of the ORACLE pupil 'types', and table 7.2 presents the characteristics of each cluster in the form of the relative frequency, high, medium, or low use of each behaviour category. (Mean frequencies of the categories for the 4 clusters are presented in Appendix 3.)

TABLE 7.1 CORRELATIONS OF EACH CLUSTER IN MATHEMATICS WITH EACH ORACLE PUPIL 'TYPE'

Cluster	1	2	3	4
Attention Seekers	0.00	-0.22	0.20	-0.57
Intermittent Workers	0.77	-0.48	0.00	0.32
Solitary Workers	-0.43	0.61	-0.28	0.52
Quiet Collaborators	-0.18	0.30	-0.52	-0.33

Cluster 1 accounted for 27.7% of the pupils in the analysis. This cluster correlates highly with the Intermittent Workers (r=0.77). The pupils are characterised by relatively low levels of interaction with the teacher but a high level of contact with other pupils. These Cluster 1 pupils worked on their task work or were engaged on routine matters for 62% of their time and were distracted from their work for 27% of their time, a relatively high proportion compared to pupils in the other clusters. Although distracted, the pupils tended to remain in their work base, for 91% of the time, and talked to pupils of their own gender and from their own workbase in the classroom. The teacher was in close proximity to, or in interaction with, the pupil for a relatively small amount of time (15%) which may support the theory that a pupil tends to cease to work when the teacher leaves his/her side. ORACLE researchers suggested that this low level of teacher presence may be due to these pupils going out of their way to avoid contact with the teacher rather than the teacher avoiding contact with the pupil, and certainly the pupils of this cluster are characterised by their relatively low levels of initiating contact with the teacher.

If the amount of teacher presence contributes to gender differences in pupil performance, then one would expect that the distribution of girls and boys in this cluster of Intermittent Workers would be opposite to the distribution in English.

Cluster 2 accounted for 20% of the pupils in the analysis. This cluster correlates most strongly with Solitary Workers (r=0.61). These pupils are involved in interaction with the teacher for a relatively high amount of the time (38%) but very little of this contact is in the form of individual attention. Contact is mainly as a member of the audience when the teacher is interacting with the whole class (31%) or when the teacher is interacting with a group of pupils (5%). As a consequence, work on task or routine is high (76% of the time) and the teacher is either close to the pupil or involved in interaction with the pupil for a large 45% of the time. When class teaching is controlled for, the extent of teacher presence is no greater than for Intermittent Workers. As the level of whole class contact is high, it is not clear whether the teacher prefers class teaching or whether certain characteristics of the pupils force the teacher to use this certain style of teaching. As class teaching is generally associated with secondary education more than primary, then it is possible that the majority of the pupils belonging to this cluster are in classes of 8+ high schools with a secondary type of organisation.

Cluster 3 accounts for 20.5% of the sample. This cluster fails to correlate highly with any of the four ORACLE primary types. A negative correlation of -0.52 resulted with Quiet Collaborators. These cluster 3 pupils are characterised by a low level of interaction with the teacher, but the interaction that does take place is in the form of individual attention which is initiated by the pupil. An average amount of contact with other pupils takes place, but work on task or routine matters is relatively low, although still 63% of the time. Time spent waiting for the teacher (14%) and being out of the work base (24%) is relatively high and suggests that these pupils may come from a class where individual work is common, these pupils choosing to queue to see the teacher. The question arises as to whether the particular teaching style leads all pupils in the class to belong to this style or whether only certain pupils choose to queue.

If the theories are true which state that girls are more reluctant than boys to approach the teacher, then one would expect these cluster 3 pupils to be boys rather than girls.

From table 7.2 the characteristics of cluster 3 pupils suggest a similarity to the type of pupil defined in the ORACLE transfer study as FUSSPOTS. Fusspots are characterised by being helpful in fetching or washing apparatus and hence spend less time on task matters but more on routine matters than the other pupil types. The results so far lead to the question of whether the observation schedule is describing pupil 'type' or describing a relationship between pupil type and teaching style. The ORACLE transfer study of secondary teachers reported that teaching style was likely to have an effect on pupil behaviour, hence pupil 'type', and that this effect was different according to the curriculum area being taught. In secondary schools however, most teachers specialise in one curruculum area whereas primary teachers teach the whole curriculum and it would be interesting to see if primary teachers affect pupils differently in mathematics compared to English.

Cluster 4 pupils accounted for 31.7% of the sample. This cluster correlates most highly with Solitary Workers (r=0.52). Although this correlation is fairly high, the pupils have relatively lower levels of interaction with other pupils than Solitary Workers and are more like the Hard Grinders of the ORACLE transfer study. These pupils are characterised by low levels of interaction with either the teacher or other pupils, and have the highest amount of time working on their task

TABLE 7.2 RELATIVE FREQUENCIES OF THE CATEGORIES FOR THE 4 CLUSTERS IN MATHEMATICS

Cluster	1	2	3	4
INIT	Low	High	High	Low
STAR	Low	Average	High	Low
PART	Low	High	Low	Low
TCHR	Low	High	Low	Low
TK WK	Low	High	Low	Low
ROUT	Low	High	Low	Low
IND ATT	Low	Low	High	Low
GROUP	Low	High	Low	Low
CLASS	Low	High	Low	Low

	1	2	3	4
BGNS	High	Low	Average	Low
COOP	High	Low	Average	Low
MTL	High	Low	Low	Low
CNTC	High	Low	Low	Low
S TK	High	Low	Low	Low
SS	High	Low	Average	Low
OS	High	Low	Low	Low
SEV SS	High	Low	Low	Low
SEV OS	High	Low	Low	Low
OWN BS	High	Low	Low	Low

	1	2	3	4
COOPTK	Low	High	Low	Low
COOP R	Low	High	High	Average
DSTR	High	Low	Average	Low
WAIT TCHR	Low	Low	High	Low
CODS	High	High	Low	Low
INT TCHR	Low	Average	High	High
INT PUP	High	Low	High	High
P IN	High	High	Low	High
P OUT	Low	Low	High	Low
P MOB	Average	Low	High	Average
POUT RM	High	Low	High	Low
T PRES	Low	High	Low	Low
T ELSE	High	Low	High	High
T MNTR	Low	High	Low	High
T HSKP	Average	Low	High	High

High (shaded) Average (cross-hatched) Low (blank) or routine matters (78%) and the lowest level of distraction (11%). In mathematics, girls are reported to have little contact with the teacher, are hard workers and eager to please the teacher, especially at the secondary age level. If this is true, then the secondary type of organised schools should show more girls than boys as Hard Grinders.

The Chi-squared test was used as a statistical measure to compare cluster membership of girls and boys. The results are presented in table 7.3.

TABLE 7.3 THE DISTRIBUTION OF GIRLS AND BOYS ACROSS PUPIL 'TYPES' IN MATHEMATICS.

	Boys	Girls	Gender not recorded	Totals
Intermittent Workers	64	74	1	139
Solitary Workers	50	44	7	101
Fusspots	58	44	1	103
Hard Grinders	72	86	1	159
	244	248	10	502

$\chi^2 = 2.73$ degrees of freedom = 3 Not significant.

No overall sex differences in cluster membership for 8-10 year olds reached significance. Slightly more girls were Hard Grinders than boys and less were Fusspots. These findings give some support to theories which suggest that girls have less contact with the teacher than boys do, are hard workers and are eager to please the teacher. This difference in levels of contact with the teacher appears to be due to boys being more demanding as a Fusspot whereas the Hard Grinder girls work on task and do not receive nor demand attention. More girls than boys are Intermittent Workers i.e. they avoid contact with the teacher, work less than other pupil types and interact frequently with other pupils. Thus it appears that two 'types' of girls avoid contact with the teacher:

1. those who are Intermittent Workers who do enough to avoid the teacher's attention but interact with fellow pupils in between bouts of working on task.
2. those girls who are Hard Grinders, work hard on task with their heads down and interact with no-one.

Boys are also mainly Intermittent Workers and Hard Grinders but less so than girls. Although the gender differences do not reach significance, these small differences may accumulate over the primary years and manifest at the secondary age in terms of the effect on performance in mathematical attainment. The ORACLE transfer study reported most pupils to be Easy Riders in mathematics i.e. pupils who do an average amount of work and also are distracted for an average amount of time, with just a few Group Toilers who work particularly hard. Fusspots were reported to be few in mathematics at the secondary level but even fewer in English. These transfer pupil types are, then, very different from the primary pupil types in which Easy Riders and Group Toilers were not produced by the cluster analysis, yet Fusspots were found in reasonably large numbers.

In conclusion, the primary mathematics data produced four clusters of pupil types

1. Intermittent Workers	27.7%	↕ ORACLE PRIMARY TYPES
2. Solitary Workers	20.1%	
3. Fusspots	20.5%	↕ ORACLE TRANSFER TYPES
4. Hard Grinders	31.7%	

Details for the clusters found in the ORACLE transfer study are not available in the same form as for the primary study so a correlation of clusters is not possible and judgement of similarity to transfer clusters has been based on the descriptions available (Galton et al,1983).

7.13.2 PUPIL TYPES IN ENGLISH

Using the data for English only of 8-10 year old pupils, four clusters resulted from the re-analysis. Table 7.4 shows the correlation figures of each of these clusters with each of the ORACLE pupil types.

TABLE 7.4 CORRELATIONS OF EACH CLUSTER IN ENGLISH WITH EACH ORACLE PUPIL 'TYPE'

Cluster	1	2	3	4
Attention Seekers	0.38	0.14	-0.46	-0.11
Intermittent Workers	-0.41	0.72	0.57	-0.63
Solitary Workers	-0.32	-0.49	0.39	0.64
Quiet Collaborators	-0.25	-0.15	-0.46	0.32

Cluster 1 accounted for 24% of the pupils in the sample. This cluster correlates highest with Attention Seekers (r=0.38) who are characterised by the relatively high level of individual contact with the teacher and the high level of time spent waiting for the teacher and being out of base. However, the relatively greater time spent on routine matters than would be expected with Attention Seekers suggests that these pupils are more similar to the Fusspots of the transfer study as described

TABLE 7.5 RELATIVE FREQUENCIES OF CATEGORIES FOR THE 4 CLUSTERS IN ENGLISH

Cluster	1	2	3	4
INIT	High	Average	Low	High
STAR	High	Low	Low	Average
PART	Low	Low	Low	High
TCHR	Low	Low	Low	High
TK WK	Low	Low	Low	High
ROUT	Low	Low	Low	High
IND ATT	High	Low	Low	Average
GROUP	Low	Low	Low	High
CLASS	Low	Low	Low	High

	1	2	3	4
BGNS	Average	High	Average	Low
COOP	Low	High	Average	Low
MTL	Low	High	Low	Low
CNTC	Low	High	Low	Low
S TK	Low	High	Low	Low
SS	Low	High	Low	Low
OS	Low	High	Low	Average
SEV SS	Low	High	Low	Low
SEV OS	Low	High	Low	Low
OWN BS	Low	High	Low	Low

	1	2	3	4
COOPTK	Average	Low	Average	High
COOP R	High	Low	Low	Average
DSTR	Low	High	Average	Low
WAIT TCHR	High	Low	Low	Average
CODS	Low	High	Average	Average
INT TCHR	Low	Low	High	Average
INT PUP	Low	Low	High	Low
P IN	Low	Average	High	High
P OUT	High	Low	Low	Low
P MOB	High	Average	Low	Low
POUT RM	High	Average	Low	Low
T PRES	Average	Low	Low	High
T ELSE	High	High	High	Low
T MNTR	Low	Average	Low	High
T HSKP	Low	Average	High	Low

High Average Low

previously. Pupils worked on their task for 57% of the time, and on routine for 12.62%.

Cluster 2 accounted for 16% of the sample. The cluster correlates highly with Intermittent Workers (r=0.72) who are characterised by the low levels of contact with the teacher but high interaction levels with other pupils. The time on task or routine matters is the lowest of the four cluster types in English (53%) and the pupils are distracted for 35.8% of the time, a very high level of distraction.

Cluster 3 accounted for 41% of pupils. This cluster correlates highly with Intermittent Workers (r=0.51). These cluster 3 pupils had low levels of teacher interaction, average levels of pupil interaction, and average time spent working on their task, and are therefore more like the Easy Riders of the transfer study - doing enough work to avoid the teacher's attention but working at a leisurely pace. Easy Riders were the most common 'type' of all the curriculum areas in the transfer study, a higher proportion found in mathematics than in English or Science. This is not so for the primary study where Easy Riders did not appear in mathematics. There is obviously a difference between mathematics and English in terms of behaviour in the classroom.

Cluster 4 accounted for 18.8% of the pupils. This cluster correlates moderately with Solitary Workers having low levels of interaction with pupils. A high amount of time was spent on interaction with the teacher as part of the audience in a class teaching situation. As a consequence there is a high on task level (nearly 80%) and low levels of distraction (10.17%). Again, this poses the question of whether pupil type is being observed or if the effect of teacher style on behaviour is being observed.

The Chi-squared test was again used as the statistical measure to compare cluster membership of girls and boys. The results are presented in table 7.6.

TABLE 7.6 THE DISTRIBUTION OF GIRLS AND BOYS ACROSS CLUSTER PUPIL TYPES FOR THE ENGLISH DATA OF 8-10 YEAR OLDS.

	Boys	Girls	Gender not recorded	Totals
Fusspots	60	71	0	131
Intermittent Workers	46	42	0	88
Easy Riders	107	115	3	225
Solitary Worker	54	42	7	103
	267	270	10	547

$\chi^2 = 2.6$ degrees of freedom = 3 Not Significant

As with the mathematics data, no sex differences reached significance. Rather more girls than boys tended to be Fusspots (high levels of work on routine tasks) and Easy Riders. The incidence of Fusspots in English is opposite to that in mathematics in that mathematics had more boys as Fusspots. The high number of girls in the group of Easy Riders is also opposite to the results for mathematics where the girls tended to be Hard Grinders. This seems to suggest that more girls work at a leisurely pace in a subject reported to be easy for them than in a subject which is more difficult. It could equally be that the style of teaching in mathematics is different from the style of teaching in English even though the teacher remains the same. Earlier in the present chapter it was suggested that if teacher presence has an effect on differential performance of girls and boys, then the distribution of girls and boys as Intermittent Workers should be opposite to the distribution in English. In mathematics, 64 boys compared to 74 girls were Intermittent Workers whereas in English 46 boys compared to 42 girls were Intermittent Workers. There is, therefore, some support that teacher presence may have a differential effect on pupil performance in mathematics compared to English.

In conclusion in English, the data produced four clusters of pupil types:

Intermittent Workers	16%	↕ ORACLE PRIMARY TYPES
Solitary Workers	18.8%	
Fusspots	23.9%	↕ ORACLE TRANSFER TYPES
Easy Riders	41%	

7.13.3 PUPIL TYPES IN TOPIC

Using the data pertaining to Topic with 8-10 year old pupils, four clusters resulted from the re-analysis. Table 7.7 presents the correlation figures of each of these clusters with each of the ORACLE pupil types.

TABLE 7.7 CORRELATIONS OF EACH CLUSTER IN TOPIC WITH EACH ORACLE PUPIL 'TYPE'

Cluster	1	2	3	4
Attention Seekers	-0.19	0.00	-0.51	0.44
Intermittent Workers	-0.61	0.68	0.36	-0.19
Solitary Workers	0.56	-0.45	0.55	-0.49
Quiet Collaborators	0.51	0.00	-0.41	-0.36

Cluster 1 accounted for 24.5% of the sample of pupils. The cluster correlates highly with Solitary Workers (r=0.56) and also with Quiet Collaborators (r=0.51). These pupils are characterised by a high level of interaction with the teacher (38.5%) and most of this contact is as part of the audience during whole class interaction. There was very little interaction with other pupils and little time spent distracted (11%). These pupils stayed in their base for 90.44% of the time and the teacher was close in proximity to, or engaged in interaction with the pupil for a relatively high proportion of time (45.5%). Again, this appears to be a situation where a high amount of class teaching was used. The question remains as to whether pupils within the same class are restricted by the teaching style and therefore forced to behave in certain ways, or if these pupils are the 'type' to concentrate during class teaching whereas others might be distracted. These pupils are like the Solitary Workers because of the low level of interaction with the teacher. ORACLE researchers reported that Solitary Workers were high in number in classes of the teaching style called Class Enquirers who are characterised by the high levels of class teaching and therefore it seems possible that these teachers use a style which so limits pupil behaviour that Solitary Workers is the only type of behaviour possible.

Cluster 2 accounted for 20% of the sample and correlates with Intermittent Workers (r=0.68). These pupils are characterised as having low levels of interaction with the teacher (9.4%) and high levels of distraction (24.29%). These high levels of distraction were the result of high levels of interaction with other pupils (more than 37%). The pupils remained in their base for a high level of time (89%), but had an average level of initiating contact with the teacher. Thus it cannot be assumed that Intermittent Workers actively avoid the teacher's attention. Time on task was 54% and routine 10% which is relatively low, but it is

TABLE 7.8 RELATIVE FREQUENCIES OF THE CATEGORIES FOR THE 4 CLUSTERS IN TOPIC

Cluster	1	2	3	4
INIT	Low	Average	Low	High
STAR	Average	Low	Low	High
PART	High	Low	Low	Low
TCHR	High	Low	Low	Low
TK WK	High	Low	Low	Low
ROUT	High	Low	Low	Average
IND ATT	Low	Low	Low	High
GROUP	High	Low	Low	Low
CLASS	High	Low	Low	Low

	1	2	3	4
BGNS	Low	High	Low	Average
COOP	Low	High	Average	Low
MTL	Low	High	Low	Average
CNTC	Low	High	Low	Low
S TK	Low	High	Low	Low
SS	Low	High	Low	Average
OS	Low	High	Low	High
SEV SS	Low	High	Low	Low
SÉV OS	Low	High	Low	Average
OWN BS	Low	High	Low	Average

	1	2	3	4
COOPTK	High	Average	High	Low
COOP R	Average	Low	Low	High
DSTR	Low	High	Low	Average
WAIT TCHR	Low	Low	Low	High
CODS	Low	High	Low	Low
INT TCHR	Low	Low	High	Average
INT PUP	Low	Low	High	Average
P IN	High	High	High	Low
P OUT	Low	Low	Low	High
P MOB	Low	Average	Low	High
POUT RM	Low	Average	Low	High
T PRES	High	Low	Low	Low
T ELSE	Low	Average	High	High
T MNTR	Low	Low	High	Low
T HSKP	Low	Average	High	Low

(Shaded) High (Cross-hatched) Average (Blank) Low interesting that the teacher was close in proximity to the pupils for only 15.84% of the time and this may support the theory that pupils stop working when the teacher leaves their presence.

Cluster 3 accounted for 39% of the sample. This cluster correlates highly with Solitary Workers (r=0.55), and although similar in terms of low interaction with other pupils, and high on task or routine (77%), the pupils in this cluster had less interaction with the teacher than did Solitary Workers (8% compared to 19%) and were more like the Hard Grinders of the transfer study. These Hard Grinders stayed in their work base for 90.85% of the time and although work levels were high on task, the teacher was in their presence for only 13% of the time sampled. These pupils, therefore, worked hard regardless of whether the teacher was with them or not. It may be that achievement levels had some effect here. If high achievers are the hard workers then teacher presence would not be so important to the progress of the pupils as it would be for pupils who were struggling and needed a great deal of help. For low achievers, those who work hard would need the teacher's extra help in order to progress, while low achievers who appeared not to work hard need the teacher present in order to minimise the levels of distraction and disorderly behaviour. Table 7.8 shows the characteristics of each cluster in the form of relative frequency of behaviour in each category.

Cluster 4 accounted for 16% of the pupils. This cluster correlates with the Attention Seekers (0.44) but the low level of time spent working on the task and high level on routine matters suggest that these pupils are more like the Fusspots of the transfer study. They are similar to Attention Seekers in the high levels of initiating contact with the teacher and high levels of waiting for the teacher while out of their work base, but they had lower levels of pupil to pupil interaction than the Attention Seekers of the primary study. This behaviour suggests a situation where pupils work individually on a task and join a queue to see the teacher.

The Chi-squared test was used to investigate pupil gender differences on cluster membership in Topic, and the results are presented in table 7.9.

TABLE 7.9 DISTRIBUTION OF BOYS AND GIRLS ACROSS THE CLUSTER TYPES IN TOPIC OF 8-10 YEAR OLDS

	Boys	Girls	Gender not recorded	Totals
Solitary Workers	56	61	8	125
Intermittent Workers	55	47	1	103
Hard Grinders	95	105	1	201
Fusspots	44	38	0	82
	250	251	10	511

$\chi^2 = 1.7$ degrees of freedom = 3 Not significant

No significant differences resulted from the analysis. Slightly less girls than boys were Fusspots or Intermittent Workers, but more girls were Hard Grinders and Solitary Workers. This shows no consistency of gender differences across curriculum areas and might suggest a link between the effect of curriculum area on behaviour of girls and boys.

In conclusion, the Topic data produced four clusters of pupil types:

Solitary Workers	24.5%	↕ ORACLE PRIMARY TYPES
Intermittent Workers	20%	
Hard Grinders	39%	↕ ORACLE TRANSFER TYPES
Fusspots	16%	

7.13.4 SUMMARY

The distribution of pupil types within each curriculum area which resulted from the re-analysis is presented in table 7.10.

TABLE 7.10 DISTRIBUTION OF THE PUPIL TYPES WITHIN EACH CURRICULUM AREA

	MATHS	ENGLISH	TOPIC	
Intermittent Workers	27.7%	16%	20%	↑Oracle Primary
Solitary Workers	20.1%	18.8%	24.5%	↓Types
Hard Grinders	31.7%		39%	↑Oracle
Easy Riders		41%		Transfer
Fusspots	20.5%	23.9%	16%	↓Types

In summary, most pupils in mathematics were Hard Grinders characterised by the higher frequency of contact with the teacher through whole class work although the distribution of pupils across several styles was fairly evenly spread. In English most pupils were Easy Riders who are characterised by the high levels of distraction and little interaction with their teacher. In Topic most pupils were Hard Grinders. From an inspection of the characteristics of these clusters it seems possible that pupil style is linked closely to the method of teaching used by the teacher. Fusspots are out of base a great deal waiting for the teacher - this could be the 'queue' at the teacher's desk. The high amount of group and class teaching which is characteristic of the Solitary Workers is teacher controlled and therefore the teaching style may be forcing certain types of pupil behaviour. Easy Riders were found only in the English data analysis which could be due to the frequent amount of individual work which tends to be used. Solitary Workers who are characterised by the high amount of class work rather than group work were found in all of the data analyses whereas Easy Riders who do just enough to avoid the teacher's attention were found only in the English data analysis. Thus these results suggest a link between pupil type, teacher style, and the curriculum area involved, but the question still unanswered is whether a certain teaching style is found restrictive by a few pupils whereas others in the class may ignore, for example, class teaching and become distracted to become labelled a different pupil type. Further investigation into this issue is presented later in the present chapter.

7.13.5 EFFECT OF JUNIOR TYPE OF ORGANISATION AND SECONDARY TYPE OF ORGANISATION ON PUPIL BEHAVIOUR.

One of the purposes of the re-analysis of the ORACLE data was to find the differences in pupil types across curriculum areas in the primary age, as the original analysis had clustered the data based on general curriculum areas. The ORACLE transfer study did compare pupil types across mathematics, English and Science. For the present study, therefore the important aspect of these analyses is the comparison of pupil types in mathematics and English from the primary to the secondary ages. Table 7.11 shows the distribution of pupil types in the transfer and the primary analyses.

TABLE 7.11 PERCENTAGES OF PUPILS IN THE CLUSTER 'TYPES' FOR MATHEMATICS AND ENGLISH IN THE PRIMARY AND TRANSFER ANALYSES.

	Mathematics		English	
	Transfer	Primary	Transfer	Primary
Easy Riders	82	0	52	41
Fusspots	7	21	1	24
Hard Grinders	6	32	35	0
Group Toilers	5	0	12	0
Intermittent Workers	0	28	0	16
Solitary Workers	0	20	0	19

In mathematics the majority of pupils in the transfer study were reported to be Easy Riders (82%) but this is not so in the primary study where no Easy Riders or Group Toilers resulted from the study and the pupils were fairly evenly spread across the four other pupils types. As Easy Riders are characterised by little interaction with the teacher and great levels of distraction, the question arises as to the teaching method being used which enables Easy Riding to occur. The ORACLE researchers found higher class interaction in transfer schools than in primary schools in mathematics and reported that class teaching was used to a greater extent than in the primary school. As more pupils sit in single sex pairs, interaction is possible with next door neighbours, sometimes quiet whispering and therefore interaction with peers may increase in the secondary schools. The ORACLE transfer study reportrd that style of teaching differed from subject to subject and there tended to be a dominance of teaching style over pupil type. There is a need, therefore, to see if pupils in a primary class change 'type' according to the area being taught, even though the teacher remains the same person. Before dealing with that aspect of the study, however, further investigation into the effect of type of school organisation (primary type or secondary) on pupil 'type' at different age groups is necessary. LEAs 1 and 3 included pupils who transferred to a High school at the age of 8 or 9 years, and LEA 4 included only pupils from a Junior school with pupils up to 11 years of age. Therefore to investigate the effects of school organisation the data from different LEAs was compared.

For each of the three analyses, mathematics, English and topic, a Chi-squared test was used to see if there was a difference in cluster membership according to the LEA involved. Tables 7.12 and 7.13 summarise the results.

TABLE 7.12 CHI-SQUARED TEST ON CLUSTER MEMBERSHIP BY LEA

	df	χ^2	Sig.
MATHS	6	46.96	.001
ENGLISH	6	66.22	.001
TOPIC	6	106.22	.001

TABLE 7.13 SUMMARY OF CHI-SQUARE SIGNIFICANT RESULTS OF THE PUPIL TYPES ACROSS THE CURRICULUM AREAS FOR EACH AGE GROUP

	Mathematics			English			Topic		
	Sec		Jnr	Sec		Jnr	Sec		Jnr
LEA	1	3	4	1	3	4	1	3	4
Fusspots				+			–		+
Interm. Workers.		–	+	–		+		–	+
Hard Grinders					+	–		+	
Solitary Workers		+	–		–			+	–

(where + denotes more of this type than would be expected by chance
- denotes less of this type than would be expected by chance
LEAs 1 and 3 includes data of pupils at a high school with an 8 or 9 years of age entry, LEA 4 contains data from pupils who are all at junior 7-11 schools.)

In mathematics, the LEA which has transfer to a high school at the age of nine years (area 3) contained more Solitary Workers (with relatively high amounts of class teaching) than would be expected and less Intermittent Workers (with high distraction levels). In contrast, the LEA which has transfer later at the age of eleven (area 4) had more Intermittent Workers and less Solitary Workers than would be expected. This then might suggest that the type of school, rather than the age of the pupil, has some influence in the pupil type derived from cluster analysis. Areas containing more pupils in a secondary type of organised school contained more Solitary Workers who are restricted in behaviour by the high level of class teaching.

In English, the area with more primary organised schools also had more Intermittent Workers but less Hard Grinders (hard workers with little interaction with teacher or pupils), whereas the areas with some transfer to secondary organised schools had more Hard Grinders and Fusspots (queue forming) but less Solitary Workers (high class teaching) and Intermittent Workers (high distraction).

In Topic, the junior data had more Fusspots and Intermittent Workers while secondary organised data had higher proportions of Hard Grinders and Solitary Workers.

Thus in a secondary organised area, higher proportions of pupil types associated with class teaching were found in mathematics than in English, and subsequently there was less distraction. In Junior organised schools, there was more distraction and little class teaching in both mathematics and English. Thus the sudden change from a relaxed junior setting to one with formal class teaching in mathematics may have led to higher anxiety levels in girls and hence poorer performance. English teachers appear to have retained a relaxed teaching approach throughout the primary and secondary ages and therefore anxiety may be minimised and will not have such an effect on girls' performance in English.

These results then, suggest that the organisation of the school (i.e. primary or secondary) affects pupil 'type' of behaviour. This supports the findings of the original ORACLE transfer study which presented tentative results to show differences in style of teaching between primary organised classes and secondary organised classes. If the style of teaching mathematics in the secondary school doesn't suit girls, perhaps due to a cause of higher anxiety, or to less opportunity to obtain help from the teacher and peers, then the restrictive practice of class teaching may be a causal factor, directly or indirectly, on girls' underachievement in mathematics.

7.13.6 CONTINUITY OF PUPIL STYLES ACROSS THE CURRICULUM AREAS IN THE PRIMARY SCHOOL

If, as it appears, it is true that pupil type is influenced by teaching style, and pupil achievement is affected also by teaching style, then the question arises as to whether pupils in a junior school are able to change their 'type' of behaviour according to the curriculum area being taught. Each pupil's style in mathematics was therefore compared to his/her style in English and also in topic. Data on pupils who were not observed in all three curriculum areas was excluded from this analysis. The total number of pupils with the same cluster membership for all three curriculum areas was divided by the total number of pupils in the analysis to obtain proportions. For example, from table 7.14, the first line of the table relates to data of 9-10 year old pupils from a 9-13 High school. For these pupils the proportion of 0.33 means that the probability of pupils being in the same cluster for all three curriculum areas is only 33 in a 1000.

TABLE 7.14 PROPORTIONS OF PUPILS BEING IN THE SAME CLUSTER TYPE FOR MATHEMATICS, ENGLISH AND TOPIC

School Type	Age	LEA	Proportion
HIGH(9-13)	9-10	3	.033
HIGH(8-12)	10-11	1	.013
JNR	8-9	3	.014
JNR	8-9	4	.053
JNR	10-11	4	.000
JNR	9-10	4	.023

From table 7.14, there was no tendency for pupil 'types' to be constant across the different curriculum areas, the proportions ranged from 0 to 53 in a 1000, so it appears that pupils changed type even though they had the same teacher for each curriculum area. The possibility remains however, that one teacher style can result in two or more different pupil types of behaviour in the same class and curriculum area. If pupils in the same class have the same cluster membership as each other within each curriculum area, then there is further support for the suggestion that the teacher's style is the dominant influence upon the pupil type of behaviour.

For each teacher, proportions of pupils in each cluster for each curriculum area can be calculated. If these values are high for certain clusters, then it may be inferred that teacher influence is likely to dominate. (See Appendix 3 for details of these values). Teachers with classes having a high proportion of missing data were excluded from the analysis leaving a total sample of 68 teachers.

Table 7.15 shows the percentage of teachers with at least half of their observed pupils in the same cluster within each curriculum area.

TABLE 7.15 TENDENCY OF PUPILS WITHIN THE SAME CLASS TO HAVE THE SAME CLUSTER MEMBERSHIP

	MATHS	ENGLISH	TOPIC
Percentage of teachers with > 50% of pupils in a common cluster	79	84	79
N	68	68	68

From table 7.15 it is clear that a high percentage of teachers have at least half of their observed pupils in the same cluster within each curriculum area. Thus for the majority of teachers their pupils tend to be in the same cluster type, but this type is likely to change according to the curriculum area involved.

As pupil types in the primary study were found to be substantially different from pupil types reported in the ORACLE transfer study for both mathematics and English, then it is likely that the style of teaching in the secondary school exerted an influence on pupil behaviour which led to underachievement of girls in mathematics, and underachievement of boys in English.

7.13.7 SUMMARY

The re-analysis lends some support to the suggestion that in mathematics girls have less contact than boys with the teacher, are harder workers, and are more eager to please. Boys tend to be more demanding Fusspots. Girls avoid teacher attention either by intermittent working (doing just enough to avoid attention but being distracted frequently), or by engaging in low levels of interaction but working hard (Hard Grinders).

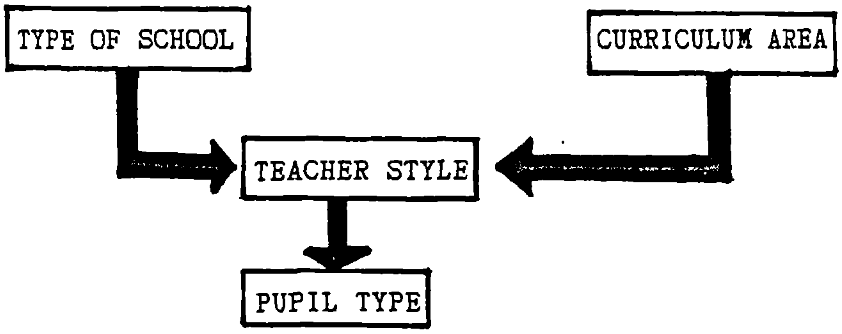
Four pupil types resulted from the analysis of the mathematics data - Intermittent Workers, Solitary Workers, Fusspots, and Hard Grinders. In mathematics there were no Easy Riders as found with the English data and this suggests that a more relaxed style of teaching was used in English than in mathematics.

A difference in the incidence of certain pupil types in junior and secondary organised schools suggests that English provides a more relaxed type of teaching at both the primary and secondary level, subsequently leading to high incidences of intermittent working. In mathematics however, although there was a more relaxed teaching style at the primary level, leading to a high incidence of Intermittent Workers, the high levels of class teaching at the secondary age leads to the high incidence of Solitary Workers. This Solitary Worker type of pupil appears not to suit girls, more girls being Intermittent *Workers in mathematics than in* English, and more boys being Intermittent Workers in English than in mathematics.

Pupils in a primary school change their 'type' according to the curriculum area taught which suggests that teaching methods change too, even when the same teacher is responsible for all curriculum areas.

Thus the findings of the re-analysis support the transfer study findings reported in 'Moving from the Primary Classroom' in which it is stated that 'for the most part the links between teaching style and pupil type can be clearly seen to be consistent from one year to the next; and this greatly strengthens the case for asserting that teaching style is a major influence upon pupil type (Galton et al,1983,p34).

This re-analysis further suggests that subject area influences teacher style which then in turn influences pupil type. However, the findings of area differences also suggest that school type (whether middle or junior) may also have some influence on the pupil type clusters and therefore the type of school may also be said to influence teacher style.



Indeed, teaching style may be such a strong influence on pupil behaviour that deriving pupil types could lead to determining which teaching style was involved i.e. teaching styles being derived at by looking at pupil behaviour.

From the above analyses boys and girls did not appear to differ significantly in the pupil type clusters to which they belong, irrespective of the particular curriculum area. The reasons for this particular result remains unclear and there are several possibilites to be investigated further. First, boys and girls may behave in exactly the same way within the classroom. This, however, is contrary to subjective reports of class teachers who report gender differences. Secondly, differences between boys and girls in classroom behaviour may be so small that cluster analysis which is based on aggregation of several behavioural variables may fail to pick up these differences. Nevertheless, small differences on one type of behaviour may accumulate and become important enough to produce effects during the teenage years. Finally, one style of teaching and pupil type may be beneficial to one of the sexes and not the other. Some support for this last suggestion has already been presented. The other possibility, whether pupil gender differences were apparent in any of the observed categories of behaviour, can be investigated using a t-test on the individual observation categories in the schedule.

7.13.8 GENDER DIFFERENCES ACROSS INDIVIDUAL OBSERVATION CATEGORIES

Both single and compound variables were used in this analysis, producing results from t-tests on about 270 variables. Significant differences which resulted from this analysis are listed in Appendix 3. On inspection of the results by chronological age, the results from the data from mathematics lessons suggest that at age 8 to 9 years few differences in pupil behaviour existed except that boys spent more of their time waiting for the teacher than girls did. This may be due to a desire for constant feedback or it might be that they finished each piece of work more quickly and needed instructions on what to do next. By the age of 9 to 10 years this difference was not apparent but boys did appear to initiate interaction with the teacher more often than girls. By this age boys may have become more direct in their approach to the teacher for feedback or guidance and demanded more attention. If boys become used to receiving the individual attention of the teacher from the infant age, then by 8 to 9 years they will approach the teacher with more confidence than girls. It was also noted that more boys sit alone but this is often for class management and discipline reasons rather than for reasons of pupil preference.

At the age of 10 to 11 more boys still sat alone and engaged in more horseplay than girls. Needless to say they also received more individual attention from the teacher but part of this would be for purposes of discipline. Girls sat in mixed sex groups and limited their interaction to pupils from their own base.

At 11 to 12 years girls still received less attention from the teacher than boys. Boys' interaction with the teacher tended to be about routine matters rather than the task in hand.

At 12 to 13 years more boys still sat alone but girls were now in pairs of the same sex.

Thus it appears that initially, boys seek interaction with the teacher and then use strategies to ensure they get the attention they desire. Girls tend to limit their interaction with the person they sit close to. Initially this interaction will take place in mixed sex groups but later it is directed to one member of the same sex. Most of the differences in attention seem linked to non-task or routine matters rather than the mathematics task itself. However, if a boy becomes accustomed to talking to the teacher, then they may subsequently become more at ease in approaching the teacher for help on task matters.

At 8 to 9 years of age, girls, during English lessons, spent more time than boys on routine matters while the boys were more distracted and disruptive. At 9 to 10 years the only gender difference was that boys were more mobile within the classroom than girls. At 10 to 11 years of age more boys sat alone while girls sat in mixed sex groups, which was similar to the mathematics findings. However, boys interacted more often with the teacher, especially about task work even though they were more easily distracted. At 11 to 12 years boys engaged in horseplay. This was the only gender difference. At 12 to 13 boys were still more distracted and more likely to sit alone. Girls had less teacher contact but worked on their task for longer periods while boys worked on routine matters and interacted with the teacher more often about such routine matters.

Most of these gender differences related to behaviour and non-task matters, except that more girls at 12 to 13 were now working on the task whereas in mathematics they were more often observed when distracted from their task and engaging in conversation with their nearest neighbour.

Results for topic were almost identical to the mathematics results with boys being distracted and getting more individual attention from the teacher, eventually leading to more boys sitting alone. It is interesting that even when boys sat alone they were still distracted more often.

Thus virtually no gender differences concerning behaviour and interaction about the task appeared in the T-Test analysis. This still leaves the question unanswered as to whether the type of teacher behaviour (in terms of style and the content of his/her interaction with pupils) affects pupils in some way, or whether the non-task behaviour differences that were found affect the pupils' ensuing attitudes and approach towards mathematics in later school years. This aspect will be dealt with in the next chapter.

Returning to the hypotheses described earlier in this chapter concerning the levels of attention given to pupils, boys received greater levels of attention from the teacher than girls but this extra attention was the subject of behaviour or routine matters rather than task activity. Little praise and criticism was observed. It was therefore not possible to investigate gender differences within these categories. This issue will be dealt with in the mathematics observation study reported in the next section.

Thus in mathematics, there was some support for the suggestion that boys have greater confidence than girls in approaching the teacher for attention whereas girls lacked the confidence to ask the teacher for support.

In English, boys interacted with the teacher more often about the task activity, and therefore received the help they needed in developing their language skills. If the thesis that girls are superior to boys in mathematics at the primary level because of superior language development is accepted then boys would appear to 'catch up' in reading achievement at the time when more formal methods of mathematics teaching are employed, an approach which apparently does not suit the girls. The question of why such methods do not suit girls so far remains unanswered. One possible explanation may be that such approaches raise levels of anxiety and have a consequent effect on the girls' attitudes to the subject.

7.2 The Observation Study of Pupil Behaviour in Mathematics

The ORACLE study began in 1975 and while the re-analysis of the data has produced some valuable evidence relating to pupil behaviour in mathematics lessons, it is possible that educational thought in more recent years has resulted in different teaching styles being employed, and hence the possibility of the appearance of different pupil types. The observation study of the present study was, therefore, important in investigating the situation in the post-Oracle years. Added to this need of up-dating information on classroom behaviour, was the need to collect data pertaining to the issues relevant to the present study - the occurrence of praise and criticism for task and behavioural activity. The following section presents the details of this follow-up observational study.

7.21 THE OBSERVATION INSTRUMENT

For all age levels the observation schedule developed by Boydell (1974,75) and employed in the ORACLE project (Galton et al, 1980) was used for this study. The observation schedule was designed to obtain information relating to interaction between pupil and an adult; interaction between pupil and pupil; pupil's behaviour in terms of task, routine or misbehaviour; mobility of pupil; and teacher's activity and position in the classroom. Details of the instrument were discussed in section 7.11 and a copy of the schedule, which focuses on interaction between pupils and teachers is presented in Appendix 3.

7.22 THE HYPOTHESES UNDER INVESTIGATION DURING THE OBSERVATION STUDY

The main hypothesis under investigation in this section was described earlier in chapter 5

> 5.14 that boys receive more attention from the teacher, in particular more criticism as well as more praise, and that this frequency of attention is related to achievement in mathematics.

In addition to this main hypothesis, and as a result of the investigation so far reported, the following hypotheses were also particularly relevant to this section of the study.

1. Boys initiate interactions with the teacher more often than girls do.

If boys become accustomed to working with close supervision by the teacher from the early years of school life, they are likely to feel more at ease in talking to the teacher and will seek the teacher's help when faced with difficulties. Girls, however, are used to working with less teacher contact and therefore are reticent about approaching the teacher in a similar situation.

2. Boys receive more individual attention in interactions with the teacher than girls do.

From 1 above, it follows that if boys are successful at initiating interactions with the teacher, they are more likely to receive individual help. In addition to this, as boys are reported to misbehave more often than girls, they will receive more individual attention from the teacher for discipline reasons. A third possible explanation for a greater level of individual attention for boys at the primary age level is the slower rate of achievement of boys in language development leading to the need for extra help in following instructions which relate to the mathematical work in which they are engaged.

3. Boys have more positive and negative feedback from the teacher.

Some researchers have reported boys to receive not only high levels of negative feedback from the teacher for discipline reasons, but also more positive feedback about work, especially in whole class question and answer situations. In comparison, girls tend to be better behaved and therefore avoid negative feedback, whilst giving correct responses in question and answer sessions is less likely to receive feedback of any kind in comparison to boys' responses.

4. Boys are more distracted and out of their place more often than girls are.

Boys have been reported to be more badly behaved than girls and subsequently to blame their own low achievement on a lack of effort rather than a lack of ability. Girls on the other hand, receive feedback mostly for reasons to do with their work, and therefore blame their own low achievement on lack of ability.

5. For boys, the teacher is physically present more often than for girls.

Researchers have suggested that pupils work conscientiously on their task while the teacher is physically present, but stop working as soon as the teacher leaves the proximity of the pupils. The evidence reported earlier in this chapter suggests that, at the primary level, this effect varies according to the achievement levels of the pupils, with low achievers being affected by teacher presence more than high achievers who are more self-motivated to work without close supervision. As girls are reported to be hard workers and eager to please in the primary school, the teacher is more likely to be supervising boys and hence being in close proximity.

7.23 PROCEDURE OF THE INVESTIGATION

7.23.1 THE OBSERVATION PROCEDURE

The target pupils were observed on six separate sessions of mathematics during one academic year. A time-sampling procedure was used for which each target was observed for an instant at 25 second intervals for 5 instances, and then this observation was repeated for another 5 instances latur in the lesson. During the ORACLE study the researchers used a small tape recorder with an earpiece sounding a 'bleep' at the instant when the observed behaviour was recorded. For the present study, a count-down stop watch was used which sounded a dull signal after each 25 second period. The target pupils were observed in a random order at each visit. At each 'instant' the target's behaviour and interaction was recorded on the observation schedule as a series of ticks against the relevant categories. For example, if the pupil was working on task at their own work base and was not interacting with anyone, then the categories to be ticked would be COOPTK (working on task), PIN (target pupil in his/her work base), and then a tick against the category describing the teacher's activity at the time, such as housekeeping (HSKP).

7.23.2 STATISTICAL METHODS

The observation data on each pupil was totalled across the six observation sessions for each category on the schedule and mean frequencies obtained. The data was then analysed using the cluster procedure contained in the Clustan system of computer programmes (Wishart,1969). The procedure was similar to that used in the re-analysis of the ORACLE data reported earlier in this chapter and therefore the results of each analysis could be compared.

T-tests were administered on each category from the schedule to compare differences between the means of boys' and girls' frequencies of behaviour.

7.24 RESULTS OF THE OBSERVATIONAL STUDY

A preliminary visit to each classroom was made in order to accustom the pupils to the presence of an extra adult sitting in the class working. Over all the visits, very few pupils appeared to be affected by the presence of an observer, but the first reaction of many pupils at each visit was to ask 'You haven't got another test for us have you, I hope?' Testing was viewed negatively by the pupils.

Identification of target pupils without the teacher or the pupils being aware of who they were was, initially, a problem. This was overcome by inspection of names on exercise books, and by some informal conversation with several pupils. All but one of the secondary schools contained classes with desks set out in twos and to identify the pupils the teacher was asked to name all of the pupils. In one class, the male teacher named the boys, then hestitated and said that he was very embarrassed to say that he only knew the names of two of the girls. Until asked to name them, he had not been aware that he had come to know the boys better than the girls. The teacher was unable to say whether this was because the boys approached him more often, or if he approached them rather than girls.

As the interaction between pupils may be affected by the number of pupils in close proximity, the seating arrangements of pupils within the classroom during mathematics were recorded and are described below.

TABLE 7.16 PERCENTAGES OF PUPILS IN THE DIFFERENT SEATING GROUPS

		Alone	2SS	2OS	SSS	SOS
INFANT	boys	0	4.4	0	26.7	68.8
	girls	10	7.5	2.5	27.5	52.5
2nd JNR	boys	0	4.6	1.5	35.4	58.5
	girls	0	4.9	1.6	4.9	88.5
4th JNR	boys	3.1	3.1	3.1	16.9	73.8
	girls	0	9.1	3.6	16.4	70.9
2nd SEC	ooys	12.7	66.7	0	15.7	4.9
	girls	16.3	65.3	1	13.3	4.1

where 2SS= the target seated with a pupil of the same sex
2OS= the target seated with a pupil of the opposite sex
SSS= the target in a single-sex group
SOS= the target in a mixed-sex group

The table above shows that at the primary level, from infants to 4th year juniors, the majority of pupils sat in mixed or single sex groups (SSS,SOS). In the infants those sitting alone tended to be girls (10%) whereas at 4th year junior level it was boys who sat alone, although here the proportion was only 3.1%. There are several possible explanations for the difference between the number of girls and boys sitting alone in the infants and 4th year juniors. If some girls were reluctant to interact with other pupils and were quieter than boys, then, initially, they would be likely to sit in the school alone by choice. In the fourth year junior classes, one strategy used by some teachers to control the behaviour of pupils was to sit 'difficult' children on their own, and therefore boys sitting alone at the 4th year may have been those with particular behaviour difficulties.

At secondary level, the majority of pupils sat in same sex pairs (2SS). Of the remainder, most pupils could be found in same sex groups (SSS) with very few in opposite sex pairs (2OS) or groups (SOS). As most of the classes were set out in pairs of desks, the opportunity to mix in a group was restricted, and the peer pressure on pupils not to sit with someone of the opposite sex was likely to be very strong. When pupils sit in pairs, the opportunity for interaction with other pupils is limited to those sitting next to them. Thus if a teacher approached the boys more often than the girls, as research suggests they do, then girls will have less opportunity to interact with the teacher when in difficulty, or will be less likely to seek help from boys who have previously received help from the teacher.

7.24.1 GENERAL FREQUENCIES

The mean frequencies of each of the categories on the observation schedule are presented in table 7.17.

TABLE 7.17 MEAN FREQUENCIES OF OBSERVED BEHAVIOUR ACROSS THE AGE LEVELS INFANTS, JUNIORS AND SECONDARY.

INIT	2.09	BGNS	7.82	COOPTK	53.04
STAR	2.45	COOP	9.30	COOP R	11.11
PART/LSWT	11.60	TRIES	0.46	DSTR	18.05
TCHR	15.74	IGN	0.21	HPLY	0.30
TK WK	14.32	SUST	2.10	WAIT TCHR	6.86
ROUT	1.11	MTL	2.59	CODS	3.22
POS	0.09	CNTC	5.70	INT TCHR	1.64
NEG	0.59	VRB	11.50	INT PUP	3.12
IND ATT	3.97	STK	18.54	RIS	2.07
GROUP	3.57	DTK	1.28	P IN	84.13
CLASS	8.59	SS	13.16	P OUT	12.4
		OS	3.45	P MOB	3.32
		SEV SS	1.89	POUT RM	0.34
		SEV OS	1.28	T PRES	28.08
		OWN BS	16.19	T ELSE	56.31
		OTH BS	3.61	T MNTR	6.33
				T HSKP	4.72
				TOUT RM	4.84

The first column of table 7.17 contains details of interactions between target pupils and the teacher. From the mean frequencies presented it is clear that the most frequent pupil-teacher interaction was with the target pupil as part of an audience while the teacher was addressing the whole class (8.59%). Most of these observed interactions were about task work with very little feedback concerning either work or behaviour. The feedback given was nearly all negative rather than positive. As so little positive or negative feedback was given to the pupils, then any immediate effect on differential performance of girls and boys in mathematics is unlikely. Any effect must therefore be an accumulated factor.

The centre column of table 7.17 contains information regarding interactions between the target pupil and other pupils. From the mean frequencies presented most of the pupil-pupil interactions appeared to be verbal with a pupil of the same sex and from the target's own work base. The use of mean frequencies means that it is unclear whether these results have been skewed by the presence of a large number of secondary pupils, where the classroom organisation tends to encourage such interactions, or whether the pattern of these results applies to all age groups. The T-test analyses, therefore, provide a means of making comparisons between the primary and secondary age groups and the results are presented in section 7.24.4.

The third column in table 7.17 presents the mean frequencies of the behaviour and mobility of the target pupils and of the teacher. Pupils were engaged on their task (COOPTK) for just over one half of the observed time. This is slightly less than the figures presented in the ORACLE primary study in which all the curriculum areas were put together in one analysis. 11% of the time was devoted to routine matters such as fetching books, sharpening pencils, etc. and for 18 % of the time the pupil was distracted. Although this figure seems high, very little of the distraction was the result of sustained interaction with other pupils and was therefore a series of stop and start bouts of verbal interaction. Pupils were in their work base for the majority of the time (84%).

Earlier in the present chapter it was suggested that teacher style influences pupil behaviour according to the curriculum area being taught. Four clusters were obtained from the re-analysis of the ORACLE data on mathematics, and the present investigation also examined whether the clusters of pupil type could be replicated in the present study. The ORACLE data was collected in the 1970s and it may be that teacher style, and hence pupil behaviour, had changed by the time of the present study in the 1980s.

7.24.2 THE CLUSTER ANALYSIS

The whole of the data from the observation study was put in the one analysis. The same procedure for the analysis was used as for the re-analysis of the ORACLE study and this has been described fully earlier in the present chapter. No further detailed discussion will therefore be presented here. Four clusters resulted from the analysis and the results were put in the form of relative frequency of use of the pupil record categories as used in the ORACLE analysis and also in the re-analysis described earlier. By assigning values of 3 for high, 2 for medium, and 1 for low frequency a correlation was obtained between the clusters resulting from the present mathematics data and those found from the re-analysis of the ORACLE data. These correlations are presented in table 7.18

TABLE 7.18 CORRELATIONS OF EACH CLUSTER IN MATHS WITH EACH ORACLE TYPE.

	New Observation Cluster			
Oracle Cluster	1	2	3	4
Fusspots	0.56	-0.09	0.08	-0.49
Intermittent Workers	-0.47	0.92	0.17	-0.34
Hard Grinders	0.05	-0.06	0.78	0.19
Solitary Workers	-0.08	-0.63	0.03	0.63

Cluster 1 accounted for 13.6% of the pupils in the sample. This cluster correlates fairly highly with the FUSSPOTS (r=0.56), the pupils being characterised by their high level of initiating interactions with the teacher (4.8%) and a relatively high level of working on routine matters (14.77) compared to the other cluster 'types'. The pupils were out of their base for a high 31% of time, of which 17% was spent waiting to interact with the teacher. If it is true that boys have more confidence than girls in approaching the teacher for help in mathematics, then it would be reasonable to expect more Fusspots to be boys than girls. The re-analysis of the Oracle data provided some support for this theory. Fusspots in the re-analysis tended to be pupils at schools with a primary rather than secondary type of organisation and the present study investigates whether the findings are replicated with a different sample of pupils.

Cluster 2 accounted for 30.4% of the sample and correlates very highly with the INTERMITTENT WORKERS (r=0.92). These pupils are characterised by the great amount of time distracted from their task (28%) during which they tended to talk to one other pupil of the same sex. The pupils are also characterised by the relatively low levels of time spent working on the task (43%). From the results presented earlier in the study, these Intermittent Workers were more likely, in the primary classroom, to be girls who do just enough to avoid the teacher's attention.

Cluster 3 accounted for 40.8% of the sample. The pupils are characterised by the low levels of interaction with the teacher (7.5%), while working on task for 58% of time. This cluster correlates strongly with the HARD GRINDERS (r=0.78) who tend to be, according to the re-analysis, girls who are eager to please and hard working.

Cluster 4 (15.2% of the sample) correlates highest with the SOLITARY WORKERS (r=0.63). These pupils are characterised by the high levels of interaction with the teacher as part of the whole class (28%), and by the high level of involvement in listening and watching the teacher (29%).

Although most pupil-teacher interactions involved the pupil as part of a class, relatively high amounts of group interaction took place too (5%). The pupils were engaged on routine matters for much less time than the other pupil 'types'.

The details of the four clusters in terms of relative use of the observation categories are presented in table 7.19 (categories which had a mean frequency of less than 1.0 were omitted from the table).

TABLE 7.19 RELATIVE USE OF THE OBSERVATION CATEGORIES BY EACH PUPIL TYPE

Cluster	1	2	3	4
INIT	High	Low	Low	Low
STAR	High	Low	Low	Low
PART	Low	Low	Low	High
TCHR	Low	Low	Low	High
TK WK	Low	Low	Low	High
ROUT	High	Low	Low	Low
IND ATT	High	Low	Low	Low
GROUP	High	Low	Low	High
CLASS	Low	Low	Low	High

	1	2	3	4
BGNS	Low	High	Low	Average
COOP	Low	High	Low	Low
MTL	Average	High	Low	Low
CNTC	Low	High	Average	Average
S TK	Low	High	Low	Low
SS	Low	High	Low	Average
OS	Low	High	Average	Low
SEV SS	Average	High	Low	Low
SEV OS	Average	High	Average	Low
OWN BS	Low	High	Low	Low

	1	2	3	4
COOPTK	Low	Low	Average	High
COOP R	High	Average	Average	Low
DSTR	Low	High	Low	Low
WAIT TCHR	High	Low	Low	Low
CODS	Low	High	Low	Average
INT TCHR	High	Low	Average	Low
INT PUP	Low	Average	High	Low
P IN	Low	Average	High	High
P OUT	High	Low	Low	Low
P MOB	High	High	Average	Low
POUT RM	Low	High	Low	Low
T PRES	Average	Low	Low	High
T ELSE	High	High	High	Low
T MNTR	Low	Average	High	High
T HSKP	Average	Average	Low	High

(Legend: shaded = High; cross-hatched = Average; blank = Low)

Given that the pupil 'types' in mathematics from the re-analysis have been replicated in the present study, it was important to investigate if the distribution of 'types' across the ages in the present study was similar to the presence of the pupil 'types' reported in the ORACLE Transfer study as well as the re-analysis in the primary study. In mathematics, the transfer study reported most pupils to be Easy Riders with just a few Fusspots, Hard Grinders, and Group Toilers. The re-analysis found primary pupils to be distributed fairly evenly across Hard Grinders, Fusspots, Intermittent Workers, and Solitary Workers.

TABLE 7.20 PERCENTAGE DISTRIBUTION OF PUPILS ACROSS THE CLUSTERS.

	Fusspots	Int. Workers	Hard Grinders	Sol. Workers
Infants	47	23	27	3
2nd JNR	6	40	42	12
4th JNR	12	29	54	4
Secondary	3	31	36	31

From table 7.20, Fusspots tended to be characteristic of the infant age, with only a few of this pupil type at the junior and secondary levels. Furthermore, the Fusspot pupil type was the most common type found at the infant age (47%). As this 'type' is characterised by high levels of demanding attention from the teacher and high levels of working on routine matters, it seems reasonable to expect Fusspots to appear at the younger age level when language skills and hence independent working have not yet developed. If the theories are correct which suggest boys gain greater confidence in approaching the teacher for help, then it would be expected that most Fusspots, particularly at the older age levels, would be boys.

The second year junior age group were evenly distributed across two pupil 'types', Intermittent Workers and Hard Grinders, with only a few pupils behaving as Fusspots or Solitary Workers. These results suggest that the re-analysis of the primary data which resulted in a more even distribution spread across Fusspots, Hard Grinders, Intermittent Workers, and Solitary Workers, failed to take into account the differences of behaviour found across the ages within the primary years.

It has been suggested that the formal styles of teaching of the secondary school do not appear to suit girls, and it may equally be that different styles of teaching at lower and upper primary ages do not suit girls. The incidence of the two pupil types of Intermittent Workers and Hard Grinders at this second year junior age suggests that the need for pupils to demand attention from the teacher has lessened.

At the fourth year junior age, most pupils were Hard Grinders characterised by low levels of interaction with both the teacher and other pupils. Other pupils tended to be Intermittent Workers at this upper junior age. The picture emerges then, of a relaxed teaching style which offers the opportunity for these pupil types to manifest; a situation of pupils engaged on individual work for considerable periods of time during which pupils can be hard grinding at their work or engaging in intermittent working. In this situation, there would also be the opportunity for queues to form of pupils waiting to see the teacher i.e. the Fusspots, and at this fourth year junior age the Fusspot pupil was the second most frequent type.

The secondary age pupils were fairly evenly distributed across three clusters, INTERMITTENT WORKERS, HARD GRINDERS, and SOLITARY WORKERS. Very few were FUSSPOTS, and the majority were HARD GRINDERS. These findings are consistent with the re-analysis of the ORACLE study, and may reflect the levels of class teaching employed by the teacher.

TABLE 7.21 PERCENTAGE DISTRIBUTION OF PUPIL 'TYPE' BOYS AND GIRLS AT DIFFERENT AGE LEVELS.

		Fusspots	Intermit. Workers	Hard Grinders	Sol. Workers
Infant	Boys	40	27	27	6
	Girls	50	19	25	6
2nd Jnr	Boys	13	25	50	13
	Girls	0	50	36	14
4th Jnr	Boys	17	25	54	4
	Girls	8	33	54	4
Second.	Boys	0	32	36	32
	Girls	6	29	35	29

From table 7.21, both girls and boys were Fusspots at the infant age with only slightly more girls than boys. At both the second and fourth year junior age, however, the few Fusspots there were tended to be boys which supports the theory that boys become accustomed to interaction with the teacher in the early school years and subsequently become more confident than girls in approaching the teacher for help.

At the second year junior age where pupils were fairly evenly distributed across Intermittent Workers and Hard Grinders, the figures of table 7.21 show that boys were the Hard Grinders and girls the Intermittent Workers. These results fail to support the notion of girls being eager to please and hard working.

At the fourth year junior age, Hard Grinders were more prevalent than at the earlier ages, but the increase was due to more girls behaving as Hard Grinders while the number of boys in this pupil type remained the same as at the second year junior age.

At the secondary age, no significant gender differences in pupil type were found, with the exception that the few Fusspots that resulted from the analysis were girls and not boys.

These results support the theory that girls are reluctant to approach the teacher for help at the primary age and therefore may be excluded from development of the basic concepts necessary for the secondary curriculum. There is no evidence at the secondary age that girls are more reluctant than boys to approach the teacher or that their behaviour was different. However, two possibilities exist; firstly, that teachers' interaction with pupils may be directed to the different genders in such a way as to have differential effects on the mathematical performance of girls and boys; secondly, the differences in behaviour of girls and boys may be influenced by achievement levels. The first of these possibilities is considered in the section on observation of the teacher later in this chapter. The second possibility is investigated in the following section.

The re-analysis of the Oracle data found a tendency for pupils within the same class to have the same cluster membership; this tendency was also investigated in the present study. Out of 31 classes in the study, 25 had four or more of the six target pupils belonging to the same cluster type. This high proportion, then, supports the suggestion that the curriculum area influences teacher style which influences pupil behaviour in the classroom. The effect of teaching style on pupil gender for the different achievement levels is investigated in the following section.

The tendency of two achievement levels to belong to the same cluster was calculated by dividing the number of similar memberships by the number of classes within the age group. That is, for each class in one particular age group, the cluster membership of, say, the high and medium achievers were compared. The number of classes in which the cluster of the high achiever was the same as that of the medium achiever was ascertained and then divided by the total number of classes in that age group. The results are presented below.

TABLE 7.22 PROPORTIONS OF PUPILS OF DIFFERENT ACHIEVEMENT LEVELS BELONGING TO THE SAME CLUSTER

Age	Girls		Boys	
	H/M	M/L	H/M	M/L
Infants	0.40	0.20	0.20	0.80
2nd Jnr	0.29	0.71	0.63	0.75
4th Jnr	0.75	0.50	0.63	0.50
Secondary	0.50	0.60	0.70	0.67
TOTAL	0.49	0.50	0.54	0.68

where H represents High achievers
M represents Middle achievers
L represents Low achievers

From table 7.22, the proportion of high and middle achiever girls who had the same cluster membership was 0.49 and the proportion of middle and low achiever girls was 0.50, a moderately high figure. The boys' results showed a total tendency to belong to the same cluster that was higher (0.54 and 0.68 respectively). However, when the age groups are taken separately, infant middle achiever girls behaved more like the high achiever girls than low achievers, whereas middle achiever boys behaved like the low achiever boys. By the 2nd year junior age a difference can be observed. Middle achiever girls behaved more like low achiever girls, whereas all boys behaved in a similar way regardless of their achievement level. From table 7.22, it is clear that all achievement levels had similar cluster memberships from the 4th year junior age upwards. These findings suggest, therefore, that some change in behaviour occurs prior to the 4th year juniors such that middle achiever girls, who initially behave like high achievers, start to behave like low achievers before all girls come to behave in a similar fashion regardless of achievement level from the fourth year juniors upwards. Boys of the middle, high and low achievement levels come to behave in a similar way immediately after the infant age and remain to do so up to the secondary age. An investigation of specific behaviour differences between the age groups will be presented in the form of a t-test analysis and the results are presented later in the present chapter.

7.24.3 SUMMARY

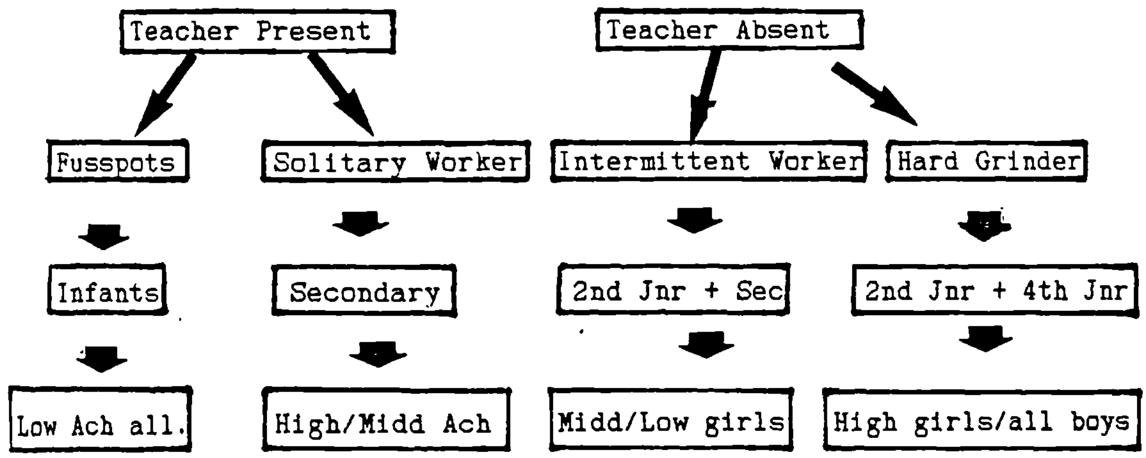
The four cluster types which resulted from the re-analysis of the mathematics data from the ORACLE study were replicated in the present observation study. The distribution of pupil types across the sample was:

FUSSPOTS	13.6%
SOLITARY WORKERS	15.2%
HARD GRINDERS	40.8%
INTERMITTENT WORKERS	30.4%

The majority of pupils were Hard Grinders who are characterised by being engaged on a task activity for a relatively high level of time, and having little interaction with either the teacher or other pupils. More girls than boys were Intermittent Workers at the junior age, spending a large amount of time being distracted from their task, but these girls tended to be the middle and low achievers. This might suggest that more boys than girls are prepared to seek or obtain help when faced with difficulties, whereas girls will become distracted and avoid the teacher's attention. Some support for this theory was found with the junior data only. As might be expected, Fusspots were found mainly in infant classes, and are characterised by the high level of time working on routine matters, a high level of time waiting for attention from the teacher, and subsequently a high level of individual attention from the teacher. Fusspots at the junior age tended to be boys thus confirming reports of other researchers that boys are more self-confident in approaching the teacher for help. Most of the Solitary Workers were pupils from secondary school classes, and these pupils are characterised by the high level of class teaching with the pupil as part of the teacher's audience.

There was a tendency for pupils in a class to have the same cluster membership as each other and this result supports the suggestion that the teacher style is influencing pupil type. No significant sex differences with regard to cluster membership were found, but there was a slight tendency for more boys than girls to be Hard Grinders and more girls than boys to be *Intermittent Workers.*

The pattern of pupil type across the classes appears to be related to the amount of time the teacher spent in interaction with the pupils, and also to the type of interaction i.e. whether whole class teaching or individual attention. A diagrammatic representation of the pattern of pupil type is presented below



From the above diagram, low achiever infants tended to be Fusspots demanding or receiving high levels of individual attention from the teacher and spending a relatively high amount of time waiting to see the teacher, being out of their workbase. There were no significant differences with respect to pupil gender, both low achiever girls and boys being Fusspots at the infant age. The findings have, therefore, failed to support the theory that teachers view boys as low achievers initially, because of language difficulties, and therefore give them more attention in mathematics leading to more confidence in approaching the teacher for help in the *future. However, the Oracle re-analysis results* did show boys to receive more help in English and it may be this attention outside of mathematics which leads to more self-confidence. The theory is, therefore, still a strong possibility, given that boys were Fusspots at the junior age.

Most Solitary Workers tended to be high to middle achiever secondary boys and girls. This suggests that in class teaching situations, it is high to middle achievers who pay attention to the teacher while low achievers engage in behaviour which is characteristic of one of the other pupil types such as an Intermittent Worker.

Most Intermittent Workers tended to be low to middle achieving girls in the second year junior and the secondary age group. These girls spent high levels of time in distraction. The high achieving girls, however, and boys of all achievement levels tended to be Hard Grinders at the second year junior level, and again at the 4th year level. These Hard Grinders had little interaction with pupils or the teacher yet worked reasonably hard. The question remains whether the pupils of different achievement levels behave in a way that has been influenced by the teacher, or whether behaviour is influenced by certain attitudes and levels of motivation. Teacher behaviour is investigated in the next section, and attitudes and motivation are investigated in chapter 8.

Cluster analysis investigates pupils with similar characteristics over several variables, and it is possible that most effective gender differences occur in individual variables. By making use of a series of t-tests it is possible to investigate such differences.

7.24.4 RESULTS OF THE T-TEST INVESTIGATION OF GENDER DIFFERENCES

A summary of the significant results are presented here. Further details can be found in Appendix 4.

TABLE 7.23 T-TEST BY PUPIL GENDER

Age	No of Pupils	Variables: Boys have higher means		Variables: Girls have higher means	
INFANTS	31	DTK		WAIT TCH	
2ND JNR	46	ROUT WAIT TCH		COOP VRB	OTHBS
4TH JUNIOR	48	WAIT TCH			
SECONDARY	60	PART NEG	CNTC THSKP		
ETHNIC MINORITY	27	CNTC OWNBS COOPR	TELSE THSKP	OTHBS	

At the infant age more girls spent time waiting to interact with the teacher while boys interacted with another pupil who was working on a different task. At the 2nd year junior age however, it was the boys waiting to interact with the teacher, while girls spent more time in verbal interaction with peers. At the 4th year, boys still waited to interact with the teacher but no other significant differences resulted.

These results are consistent with the cluster 'types' of Fusspots where the extra attention demanded by boys does not appear at the infant age. Contrary to expectation, girls demanded extra attention at the infant age, perhaps needing confirmation of success before continuing with their work. At the junior age however, boys did demand more attention by waiting for the teacher but they did not necessarily get it.

At the secondary age, boys had more interaction with the teacher as part of a group, received more negative feedback about behaviour and routine matters from the teacher, and also had more interaction with a pupil by means of physical contact. This finding supports the theory that boys may become accustomed to negative feedback and blame low achievement on lack of effort rather than lack of ability.

The observation of pupils of multi-ethnic backgrounds showed boys to have more physical contact with another pupil and spent more time on routine matters, but few differences were found between this primary school data and the other primary data. The t-test by teacher gender produced a greater number of significant results.

TABLE 7.24 VARIABLES RESULTING IN SIGNIFICANT DIFFERENCES IN THE T-TESTS WHEN TEACHER GENDER WAS COMPARED

Age	Variables: Fem. tchrs. have higher means		Variables: Male tchrs have higher means	
INFANTS			BGNS TRIES MTL CNTC	STK OWNBS CODS TOUT RM
2ND JNRS	COOPTK	TMNTR	TKWK	CLASS
4TH JNR	PART ROUT COOPR	PMOB POUTRM	INT TCH PIN THSKP	
SECOND.	PART NEG	CNTC THSKP		
ETHNIC MINORITY	CNTC OWNBS COOPR	TELSE THSKP	OTHBS	

It must be noted that, at the infant age, there were more female teachers than male teachers in the study. At the infant age level, pupils with a male teacher spent more time interacting with other pupils than those with a female teacher. It appears that male infant teachers used a freer style of teaching than their female counterparts. However, the male infant teachers tended to be deputy heads teaching infants for the first time, and therefore the samples are not truly comparable.

At the 2nd year junior age, pupils with a male teacher were involved in more class teaching while pupils with a female teacher spent more of their time working on task with the teacher monitoring the whole class. The style of teaching appears, therefore, to be different for male and female teachers.

In the 4th year juniors, pupils of male teachers spent more time in their base and the teacher was engaged in housekeeping duties more often than his female counterpart who allowed greater mobility of the pupils and more routine activities.

Few differences emerged at the secondary age. Pupils of female teachers interacted with the teacher as part of a group and received more negative feedback than pupils of a male teacher.

At the primary multi-cultural school, female teachers allowed more routine activities and pupil interaction.

These findings suggest, therefore, that teacher gender may be related to the teaching style employed, and may result in some differential behaviour of boys and girls such that development in mathematics is affected. The following section presents the results of the observation study of the teacher.

7.3 The Observation Study of the Teachers.

By observing the teacher rather than the pupils, the characteristics of the Fusspots and the Solitary Workers should be reflected in the observation results whereas Intermittent Workers and Hard Grinders, who do not have large levels of interaction with the teacher, would be less likely to be reflected in the results. It was expected that

1. the Infant age results would reflect high levels of individual contact with Fusspot pupils.

2. the Second year junior age results would reflect low levels of interaction with pupils as the majority of pupils are mainly Intermittent Workers or Hard Grinders.

3. the Fourth year junior results also to reflect low levels of interaction associated with Hard Grinders.

4. the Secondary age results to reflect high levels of class teaching which would result in the opportunity for pupil behaviour of the Solitary Workers, who have low levels of interaction with other pupils, and Intermittent Workers, who engage in start-stop bouts of working.

The present section considers the following questions

1. Do infants seek approval for work, help, or routine matters?

2. Is the low level of interaction with each pupil in the junior age, which was noticeable from the frequencies of behaviour presented earlier, due to the style of teaching e.g. where class teaching would lead to high levels of teacher contact, group or individual teaching would lead to low levels of teacher contact.

3. Do secondary teachers engage in greater levels of class teaching, a formal style which doesn't seem to suit girls?

The main hypotheses being investigated in this observation study is

5.14 that boys receive more attention from the teacher, in particular more criticism as well as more praise, and that this frequency of attention is related to achievement in mathematics.

5.15 that teachers ask boys more open-ended questions in mathematics thus developing analytical thinking, but teachers ask girls more closed-type questions which relate facts and does not develop analytical thinking.

Given that girls and boys are reported to behave differently in classes of male and female teachers, then it would also be expected that male and female teachers, perhaps by nature of their personality and their past experience, would also act differently. If girls model themselves on female teachers and boys on male teachers, then it follows that differences in behaviour of male and female teachers may contribute to the cause of girls' underachievement in mathematics. Within each of the main hypotheses listed above, therefore, there are more specific hypotheses. These are listed below:

5.15.1 male teachers praise work or effort more than female teachers

5.15.2 male teachers give more feedback (positive or negative) on work or effort than females.

5.15.3 female teachers use more critical control than male teachers.

5.15.4 female teachers refer to routine matters more than males.

5.15.5 boys get more negative feedback for behaviour than girls do.

5.15.6 boys initiate interactions with the teacher more often than girls do.

5.15.7 girls get feedback on computation while boys get feedback on analytical skills.

7.31 PROCEDURE OF THE INVESTIGATION

7.31.1 THE OBSERVATION PROCEDURE

The teachers were observed during six separate sessions of mathematics during one academic year. These sessions coincided with the visits for observation of pupils. A time-sampling procedure was used during which a teacher was observed for a continuous interval of 30 seconds. This observation was repeated a further four times throughout the session, alternating with an observation period of the pupils. This pattern of observation ensured a sample of teacher behaviour from different stages of the lesson. A count-down watch was used to time the observation intervals. A dull signal sounded after a 30 second period. During each 30 second period the interaction between the teacher and pupils was recorded using an instrument designed for the present study.

7.31.2 THE OBSERVATION INSTRUMENT

The instrument used for observation was based on ideas for an instrument developed and described by Fey (1970). Fey's instrument was based on an original idea by Smith, Bellack and Wright which analysed pedagogical function, duration, content, mathematical activity and purpose of each utterance made by the observed subject. Fey attempted to develop an instrument to describe the pedagogy and mathematical components of teacher-pupil verbal interaction, and to use it to describe patterns of verbal communication in several classrooms. He used a coding system such that each coder was required to memorise a code for each *description of* the entire interaction. For the present study, this method was considered cumbersome and also difficult to analyse. As a computer would be used in the present study for analysis, an observation schedule was devised such that the observer could put a series of ticks in relevant category boxes to describe each interaction. Each column, called a 'movement', describes who is talking to whom and about what.

The main categories on the schedule were:

SPEAKER: to describe who was speaking

AUDIENCE: to describe who was listening to the speaker

CONTENT: to describe the *type of interaction e.g. questions, giving* information, routine or behavioural concerns.

MATHEMATICAL ASPECT: to describe the purpose of the interaction such as developing a concept, illustrating a concept.

Within each of these main categories were several sub-categories which described in detail the content of the interaction. Figure I represents the observation schedule's main category of SPEAKER and definitions of each sub-category are presented below.

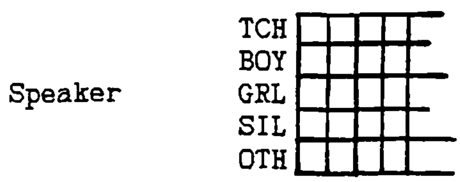


Figure I

TCH - the teacher is speaking

BOY - a male pupil is speaking and the teacher is either monitoring the interaction or actively engaged in the interaction

GRL - a female pupil is speaking and the teacher is either monitoring the interaction or actively engaged in the interaction

SIL - the teacher is not involved in any verbal interaction

The main category of AUDIENCE describes who the speaker is addressing during the interaction. The sub-categories of AUDIENCE are shown in Figure II

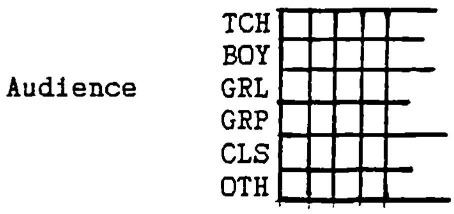


Figure II

TCH - the teacher is being addressed by the speaker

BOY - a male pupil is being addressed by the speaker

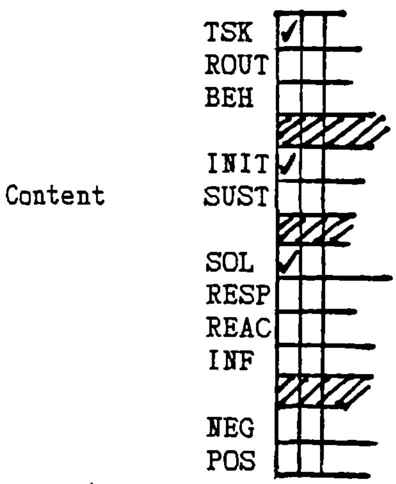
GRL - a female pupil is being addressed by the speaker

GRP - a group (2 or more pupils) is being addressed by the speaker

CLS - the whole class is being addressed by the speaker

OTH - some other person (ancillary, secretary, head) is being addressed by the speaker.

The third main category of the schedule, CONTENT, describes the interaction in terms of it's content. The sub-categories are presented in Figure III



For this section, a tick in each of four sub-categories may be required to describe the interaction. For example the ticks shown indicate the interaction has just been initiated, is about task work and the speaker is asking a question

Figure III

TSK: the interaction is directly concerned with the mathematical task. Anything to do directly with the work in hand but not management (fetching and taking) of materials.

ROUT: the interaction is directly concerned with a routine matter, classroom management or materials e.g. pencil sharpening, 'It's playtime'.

BEH: the interaction concerns a pupil's behaviour and social control.

INIT: a new interaction has just been initiated.

SUST: the interaction is sustained and is a continuation of previous interaction i.e. a different category of content.

SOL: the speaker is soliciting a response i.e. asking a question

RESP: the speaker is responding as a result of a solicitation.

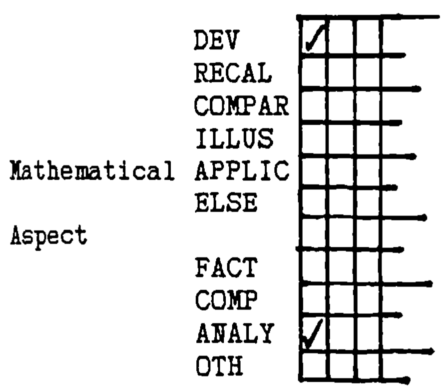
REAC: the speaker is reacting to the preceding interaction, or reacting to non-spoken *interaction e.g. the teacher might react to bad* behaviour of a pupil, or to observed task work.

INF: the speaker is providing information

NEG: the interaction has a negative tone. Usually used by the teacher as a reaction to bad behaviour or poor work.

POS: the interaction has a positive tone, either towards work or behaviour.

The final main category describes the mathematical aspect involved in the interaction. The sub-categories are presented in Figure IV



For this section, one tick in each sub-category is needed to describe the type of mathematics involved. For example, the ticks shown here indicate the the interaction was in relation to the development (DEV) of analytical skills (ANALY)

Figure IV

DEV: Developing a new concept

RECAL: Recalling from memory previously learned skills or knowledge

ILLUS: Illustrating or giving an example of a general problem in a mathematical system

APPLIC: Application of one of the categories below to mathematical or non-mathematical problems

ELSE: Any interaction which doesn't fit into the above categories

FACT: A fact, a piece of knowledge is the central mathematical part of the interaction

COMP: Computation is the central mathematical part of the interaction

ANALY: Some analytical skill is the central mathematical part of the interaction

OTH: Any interaction which doesn't fit into the above categories

The first column of boxes on the observation schedule records the interaction concerned with the first speaker, and when either the audience or speaker changes, the second column is used to record the new interaction. If the teacher is not engaged in interaction, SILENCE is coded and no other ticks are required. The number of changes, called 'Movements', could vary for each 30 second observation depending on the speed of verbal exchanges throughout the interaction.

7.31.3 STATISTICAL METHODS

The observation data for each teacher was analysed using a 'Movement' as the measure rather than the 30 second observation. The results, therefore, indicate regularity of occurrence and not the length of time involved for each category type. The data was analysed using the SPSS system of computer programmes (Wishart,1969).

General frequencies were obtained, and then the data was re-formed into a single variable describing the speaker, audience, and whether task, routine or behaviour was involved. The second variable described the interaction in terms of initial or sustained interaction. The third variable described the interaction content in terms of questions, responding, reacting, or informing. The fourth variable described the feedback, and the fifth the mathematical content. For example, TBT on variable 1 would indicate the teacher (T) was speaking to a boy (B) about the task (T). TCR would indicate the teacher (T) was speaking to the whole class (C) about a routine (R) matter. On variable five, DA would indicate the development (D) of analytical skills (A); AC would indicate the application (A) of computation (C). These variables were then cross-tabulated and the Chi-square test used to compare teacher interactions across pupil ages in relation to interactions with individuals, groups, or the whole class, the types of interactions, and the mathematical purposes involved. The frequency of negative and positive feedback to boys and girls was analysed in relation to age and type of mathematics i.e. analytical or computational, and differences between male and female teachers were investigated by comparison of use of each category in terms of percentage frequency. The frequency of movements for each observed period of 30 seconds was calculated.

7.31.4 RESULTS OF THE OBSERVATION STUDY OF TEACHERS

Inconspicuous observation of the teacher presented a few more problems than did the observation of pupils. While the teacher was addressing the whole class, the content of the interaction could easily be determined and recorded. In situations in which the teacher was seated at the desk dealing with individual pupils, this was also not too dificult to hear the content of the interactions, but in some cases the pupils did not speak but placed their exercise book in front of the teacher and waited for a reaction. When it was impossible to determine the content from the interaction, it was necessary to look at the exercise book as soon afterwards as possible. Most of the classrooms were small and therefore three observation points were found to be a satisfactory number from which to hear the teacher engaged in most interactions. Movement of the observer from one observation point to another was a practice used for observation of both pupils and teacher, and therefore the teacher and pupils became accustomed to this occasional movement. During the observation intervals, some teachers participated in bouts of rapid question-answer sessions while other teachers were involved in long periods of silence or single comment interactions. To compare this aspect of teacher behaviour with different pupil ages table 7.25 presents the frequency of movements per 30 second period.

TABLE 7.25 PERCENTAGE FREQUENCIES OF NUMBER OF MOVEMENTS FOR EACH AGE GROUP

No. of Movements	Infants	2nd Jnr	4th Jnr	Secondary
1	4.4	2.6	17.5	19.9
2	6.5	7.2	11.5	10.7
3	36.2	33.9	41.0	33.8
4	36.0	33.9	25.1	26.8
5	16.9	14.3	4.4	7.0
6	0	6.0	0.5	1.8
7	0	2.1	0	0
N	589	681	1281	1904

For all age groups, three or four movements in each 30 second interval was the most frequent rate of the verbal exchanges. The sustained periods of observation during which there were only one or two movements appeared to be characteristic of teachers with older pupils - fourth year junior and secondary - whereas rapid fire exchanges was characteristic of infants and second year junior teachers. This rapid fire exchange could be with one pupil, or the teacher constantly changing audience from one pupil to another during the interactions. Table 7.26 presents the frequencies of initiated and sustained interactions for each age group.

TABLE 7.26 PERCENTAGE FREQUENCES OF INITIATED AND SUSTAINED INTERACTIONS

	Infants	2nd Jnr	4th Jnr	Secondary
Init	46.0	42.9	38.7	39.2
Sust	54.0	57.1	61.3	60.8

$\chi^2 = 12.9$ df = 3 Significance $p<0.005$

Infants experienced slightly shorter durations of interaction than older age pupils, with slightly less than half of all observed interactions being 'initiated' rather than 'sustained', compared to 39% of the secondary age interactions. The Chi-square test yielded a significant difference by age of $p<0.005$.

The analysis of pupil behaviour provided evidence that most infants were of the Fusspot pupil type, characterised by high levels of time spent on routine matters, a high level of time waiting for attention from the teacher, and subsequently a high amount of individual attention from the teacher. The picture emerges, then, of the teacher constantly being bombarded with requests for attention from most of his/her pupils. To deal with this high level of demand, the teacher responds quickly and in short bursts to each pupil. Given this 'reacting' to demand for attention, the question remains as to whether boys were more successful than girls at getting the teacher's attention, ard also whether the attention was mainly for routine matters as the pupil type Fusspots suggests.

The following table presents details of who was speaking to whom and about what, in terms of frequency of occurrence at each of the age groups.

TABLE 7.27 PERCENTAGE FREQUENCIES OF INTERACTIONS WITH EACH AGE GROUP

Variable	Infants	2nd Jnr	4th Jnr	Secondary	
BTB	0	0.3	0	0.3	
BTR	2.4	1.6	2.7	1.4	Boy to teacher
BTT	6.3	8.6	9.3	10.0	
GTT	0.9	0.8	0.4	0.4	Group to teacher
LTR	2.4	2.2	1.9	0.3	
LTT	5.1	8.9	8.9	7.0	
TBB	2.8	2.5	1.7	2.5	Teacher to boy
TBR	6.1	5.8	4.8	3.7	individual
TBT	18.2	19.3	18.0	20.0	
TCB	0	0.6	0.6	1.5	Teacher to
TCR	1.6	2.7	2.3	4.1	whole class
TCT	1.7	2.4	6.0	10.1	
TGB	1.0	0.3	0	0.4	Teacher to group
TGR	5.2	1.3	1.9	0.9	
TGT	10.8	6.4	7.5	2.0	
TLB	1.6	0.4	0.4	0.9	Teacher to girl
TLR	7.3	5.4	4.8	2.3	individual
TLT	15.9	19.2	13.9	14.7	
S	10.5	11.0	14.9	18.0	

At all age levels slightly more boys than girls spoke to the teacher about task matters, but the greatest gender difference was at the secondary age, with 10% of all observations being 'boy to teacher' interactions about task, and only 7% of all observations being 'girl to teacher'. There were few gender differences in interaction about routine matters, with only slightly more 'boy to teacher' interactions than 'girl to teacher'. Comparing interactions from the teacher to boys and girls, the greatest differences appeared at the secondary age with 20% of the interactions with boys, and 14.7% with girls. Gender differences in favour of boys occurred at all the ages but to a lesser extent at the primary than the secondary age.

The levels of interaction from the teacher to a pupil about routine matters was greatest, as would be expected with a high Fusspot incidence, thereafter monotonically decreasing as age increased.

At the secondary age, routine matters tended to be dealt with by talking to the whole class rather than by dealing with individuals. Group interaction was characteristic of the infant age and was rarely observed at the secondary age, while whole class interaction increased throughout the ages to reach a high level at the secondary age. These results illustrate a difference in teaching style according to the age of the pupils with younger pupils experiencing a freer style involving group work, and older pupils experiencing a more formal class teaching approach. If one style of teaching (for example a freer style) suits girls more than another style, then one would expect secondary age girls in the present study to have performed poorly in comparison to boys in the Bristol Achievement Test (see chapter 6). This was not, however, the case. Thus for teaching style to have any effect on pupil performance it must be in the way it affects pupil attitudes and liking of mathematics such that girls fail to choose to study mathematics at a high level of achievement.

The slightly higher level of interactions between a teacher and a boy than between a teacher and a girl gives some support to the theory that boys become accustomed to talking to teachers and hence are more likely to approach the teacher when needing mathematical help. Boys also received more interactions relating to behaviour, and this result may support the theory that boys become accustomed to negative feedback for some reasons other than task, that lack of success is attributed to lack of effort not ability, whereas girls don't get this negative feedback and attribute failure to lack of ability. In order to investigate this theory further it is necessary to determine the proportions of interactions of the teacher to boys and girls in the present study for behaviour, task, or routine matters.

The following table presents the frequency of all interactions from the teacher to the pupil which referred to task, routine, or behavioural matters.

TABLE 7.28 PERCENTAGES OF THE TYPE OF TEACHER TO PUPIL INTERACTIONS AT THE DIFFERENT AGE GROUPS

Task	Infants				2nd Jnr			
	Boy	Girl	Group	Class	Boy	Girl	Group	Class
Behaviour	3.9	2.2	1.4	0	3.8	0.7	0.4	0.9
Routine	8.5	10.1	7.2	2.2	8.7	8.1	2.0	4.0
Task	25.0	22.0	15.0	2.4	29.1	28.9	9.6	3.6
Total %	37.4	34.3	23.6	4.6	42.6	37.7	12.0	8.5

Task	4th Jnr				Secondary			
	Boy	Girl	Group	Class	Boy	Girl	Group	Class
Behaviour	2.8	0.6	0	0.9	4.0	1.4	0.6	2.4
Routine	7.8	7.8	3.1	3.7	5.8	3.6	1.4	6.4
Task	29.0	22.4	12.1	9.7	31.6	23.3	3.2	16.1
Total %	39.6	30.8	15.2	14.3	41.4	28.3	5.2	24.9

From table 7.28 interaction on behaviour and task matters was more frequent with boys than girls, with a slightly higher level of interactions on routine matters being with girls. These differences were small and failed to reach significance, but the possibility remains that even small differences can be important enough to accumulate in effect throughout the primary years. Group interaction was used for task and routine matters.

At the second year junior age, there was a higher level of interaction with individual children than at the infant age at the expense of group interaction, whose frequency was halved. As with the infants, slightly more boys interacted with the teacher than girls, but the biggest difference was in the level of interaction about behaviour, with boys involved in 3.8% of the interactions and girls only 0.7%. Group interaction was used mainly for task purposes while routine matters tended to be dealt with on an individual basis. Less routine interactions took place than at the infant age.

At the fourth year junior age there was an increase in whole class interactions at the expense of individual interactions. Boys had considerably more interactions with the teacher than girls (39.6 compared to 30.8), mainly about behavioural and task matters. The level of group interaction remained similar to that of the second year junior age and was similarly used for matters related to task. Whole class interaction, however, which had nearly doubled in frequency to that of the second year juniors, was used mainly for task matters, with routine being dealt with on an individual basis.

The secondary age results indicate much more whole class interaction took place than at the earlier age levels (25% of the interactions), and significantly more individual interaction with boys than with girls for behaviour, routine and task matters. Group interactions were relatively rare but the level of whole class interactions was highest than at any of the other ages, almost double that of the fourth year junior age. Class interactions at this secondary age were mainly for task purposes but also a substantial amount related to routine matters.

Thus the change in style of organisation of teaching across the different age levels is evident from the results presented so far. Lower age pupils were presented with high levels of group work and little whole class interaction, whereas older pupils had high levels of class interaction but lower group interaction. Individual interactions remained at a similar level throughout the age levels.

Alongside these changes in teaching style was the increase in differential amounts of interaction with boys and girls. From the fourth year junior age upwards, more boys than girls were involved in significantly more interaction from the teacher to pupil, consistently for behavioural and task matters. It seems likely, therefore, that the teaching style employed affected the levels of interaction with boys and girls. As the style became more formal, characterised by higher levels of interaction by class and less by group, so more 'pupil to teacher' and 'teacher to pupil' interactions with the teacher involved boys than girls.

The above results are based on the total sample of teachers and as most primary teachers are female and have been said to act as models for girls, it might be that male and female teachers employ different teaching styles. Given a difference in style this might subsequently affect the differential performance of boys and girls in mathematics. The following section investigates interaction between male teachers and pupils and female teachers and pupils.

7.31.5 INFLUENCE OF TEACHER GENDER ON INTERACTIONS WITH PUPILS

As part of the investigation into the effect of teacher gender on interaction between the teacher and pupil the percentage frequencies of teacher interactions with pupil or groups of children are presented in table 7.29.

TABLE 7.29 PERCENTAGE FREQUENCES OF BEHAVIOUR VARIABLES BY AGE AND BY TEACHER GENDER

Variable	Infants		2nd Jnr		4th Jnr		Secondary	
	female	male	female	male	female	male	female	male
BTR	1,2	5,1	1,3	1,8	0,9	1,0	0,5	0,51
BTT	6,1	6,2	9,3	7,9	3,6	3,1	3,5	3,6
LTR	2,4	2,2	2,6	1,8	0,7	0,7	0	0,2
LTT	6,1	2,2	7,3	10,0	4,1	2,5	2,0	3,1
TBB	3,2	1,7	4,0	1,3	0,5	0,7	1,1	0,8
TBR	4,4	9,6	5,3	6,1	1,8	1,7	1,1	1,6
TBT	20,4	11,2	8,2	5,2	19,9	18,5	7,6	6,9
TCB	0	0	1,0	0,3	0,4	0,1	1,1	0
TCR	1,9	0,6	3,0	2,4	0,7	0,9	1,9	1,0
TCT	2,4	0	0	4,2	2,0	2,2	3,2	4,3
TGB	1,2	0,6	0	0	0,3	0,3	0,3	0
TGR	3,4	9,0	2,0	0,8	0,9	0,6	0,3	0,4
TGT	8,3	15,7	1,4	3,4	10,6	2,9	1,0	0,5
TLB	1,0	2,8	0,7	0,3	0,2	0,1	0,1	0,6
TLR	6,3	12,7	4,3	6,1	2,3	1,3	0,5	1,2
TLT	18,7	7,9	18,5	19,3	5,7	4,4	3,6	7,3

(where the first letter of the variable indicates the speaker e.g boy (B), girls (L), teacher (T), the second letter indicates the audience, and the third letter indicates the content e.g. routine (R), task (T), behaviour (B))

At the infant age, both girls and boys were more likely to have an interaction with a female teacher about a task matter but a male teacher about a routine matter. This suggests, therefore, that a different teaching style was employed such that female teachers emphasised task matters and men routine. As the Fusspot type of pupils was typicallyinvolved with routing exchanges, then pupils of male teachers would have greater opportunity to behave in the manner of a Fusspot. These results are consistent with those of the observational study of the pupils. Female teachers gave feedback about behaviour to boys while male teachers gave such feedback to girls. As was stated earlier in the present study, the samples of male and female teachers at the infant age were not matched and therefore the results cannot be taken as conclusive evidence of differential treatment of infant pupils of male and female teachers.

At both the junior ages and the secondary age, girls interacted with male teachers about the task, a result which reversed the trend in the infant study, while boys interacted with female teachers about task maintaining a similar pattern to the infant sample. These findings suggest, therefore, that interactions about task matters tended to be between the teacher and the opposite sex pupil. As most primary teachers tend to be female, it follows that girls are less likely to interact about task than boys.

To summarise, it has been established that boys are more likely than girls to interact with the teacher about task matters, regardless of whether the interaction is from a boy to the teacher or the teacher to a boy, and that teaching style appeared to change with age of pupils, becoming more formal judged by the amount of class teaching.

It has also been established that more boys are involved in interactions related to behaviour. If this interaction about behaviour is in the form of negative feedback, then there would be some support for the theory that boys become accustomed to negative feedback and attribute failure to lack of effort and success to ability. Differences in behaviour of pupils according to teacher gender have also been established. The research cited earlier suggested that boys receive more feedback, both positive and negative feedback generally, and that male teachers give more feedback for work and effort than female teachers. Because of the importance of praise and criticism on pupils' attitudes, a further investigation into the occurrence of feedback is presented in the following section.

Table 7.30 shows the percentages of positive and negative feedback given to pupils at the different age levels.

TABLE 7.30 PERCENTAGES OF THE USE OF POSITIVE AND NEGATIVE FEEDBACK AT THE DIFFERENT AGE LEVELS

Feedback	Infants	2nd Jnr	4th Jnr	Secondary
Positive	29.3	53	32	22
Negative	70.7	47	68	58
N	75	89	53	80

$\chi^2 = 13.8$ df=3 Significance $p<0.005$

From table 7.30, it appears that infants received a much higher level of negative than positive feedback. At the second year junior age however, equal amounts of positive and negative feedback were given, while at the fourth year junior age and above, negative feedback was again the more common occurrence. Table 7.31 presents teacher gender differences as they relate to the use of feedback.

TABLE 7.31 RAW SCORES OF MALE AND FEMALE TEACHERS' USE OF POSITIVE AND NEGATIVE FEEDBACK

Feedback	Infants		2nd Jnr		4th Jnr		Secondary	
	Male	Female	Male	Female	Male	Female	Male	Female
Positive	12	10	26	21	8	9	4	18
Negative	12	41	19	23	18	17	26	32
χ^2	10.39		0.8		0.2		4.2	
df	1		1		1		1	
Significance	0.03		NS		NS		0.05	

At the infant age, female teachers gave significantly more negative feedback than male teachers ($p<0.03$), and at the secondary age, while both male and female teachers gave similar levels of negative feedback, females gave significantly more positive feedback. Researchers have suggested that boys get more feedback generally, but specifically for behavioural matters and also for task matters related to analytical thinking, whereas girls receive feedback which is specifically for computation. Table 7.32 presents the figures to show the incidence of such feedback.

TABLE 7.32 INCIDENCE OF POSITIVE AND NEGATIVE FEEDBACK TO GIRLS AND BOYS FOR ANALYTICAL AND COMPUTATIONAL TASKS (RAW SCORES)

	INFANTS				2nd JUNIOR			
	Analytical		Computational		Analytical		Computational	
Feedback	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl
Positive	4	4	2	8	13	4	3	13
Negative	8	6	5	3	5	2	3	2

	4th JUNIOR				SECONDARY			
	Analytical		Computational		Analytical		Computational	
Feedback	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl
Positive	7	4	4	1	12	3	4	1
Negative	5	1	9	2	5	7	3	4

At the infant age, girls received more positive feedback for computation and boys received more negative feedback. Both girls and boys received negative feedback for analytical skills. If the data is consistent with boys receiving more negative feedback for behavioural matters, then it would lend some support to the theory that boys become accustomed to negative feedback and attribute effort as a cause of failure, thereby retaining a high self-concept of their ability. There was however, no evidence at the infant age to suggest that higher cognitive levels of mathematics were emphasised to boys by means of boys receiving significantly more feedback than girls in analytical skills.

At the second year junior age, boys received both more positive and more negative feedback on analytical skills, while girls received more positive feedback on computational skills, and this result confirms the earlier research findings. At the fourth year junior age boys received more positive and negative feedback on analytical skills and also on computational skills. Girls received very little feedback at all. This pattern is not repeated at the secondary age where boys received more positive feedback on analytical skills, but both girls and boys received negative feedback equally. In computation, very little feedback was given at this age but boys received more positive feedback and both girls and boys received negative feedback equally.

These results confirm findings of research cited earlier that boys receive feedback, whether positive or negative, for analytical skills thereby emphasising the higher cognitive demands, whereas girls receive feedback for computational skills requiring a lower level of aptitude.

Other researchers (e.g. Fennema and Sherman, 1977) have suggested that interaction with boys, especially in the form of asking questions, tends to be more often concerned with analytical skills whereas girls are involved in interactions concerning lower cognitive skills of computation.

In order to obtain a picture of the variation in type of interaction across the different age levels, the Chi-square test was used and these results are presented in table 7.33.

TABLE 7.33 THE INTERACTION TYPE ACROSS THE AGE GROUPS

Type	Infants	2nd JNR	4th JNR	Secondary
SOLICIT	32	28.2	28.0	30
RESPOND	13.5	21.0	17.4	17
REACT	17.9	21.5	16.1	16.6
INFORM	36.1	29.2	38.5	36
n	502	599	447	655

$\chi^2 = 22.6$ df=9 Significance $p<0.010$

For infants there were lower levels of 'responding' than the other age groups but similar use of the questioning category. It would appear that the teachers either failed to respond to a pupil 'soliciting' interaction or the pupils failed to respond to a question from the teacher. Both possibilities are investigated later in the present chapter.

The second year juniors were involved in higher levels of both 'responding' and 'reacting' and lower levels of 'informing' than the other age groups, although the levels of 'soliciting' were no greater. The possibilities in this instance are that the teacher responded or reacted to most pupils' soliciting, or the pupil was more likely to respond and react to teacher questions, or the 'reactions' related to non-verbal soliciting such as bad behaviour.

Researchers have also suggested that teachers treat boys and girls differently in terms of the content and style of questions employed. To investigate the content of these interactions in some depth, details of the type of mathematical tasks that were involved in all observed interactions are presented in table 7.34.

TABLE 7.34 PERCENTAGE FREQUENCIES OF TYPE OF MATHEMATICS CONTENT INVOLVED IN INTERACTIONS BETWEEN PUPIL AND TEACHER

TYPE	Infants	2nd Jnr	4th Jnr	Secondary
APPLIC/ANALY	0.3	0	13.2	27.0
APPLY/COMPUT.	5.1	14.5	29.2	11.3
APPLY/FACT	0.9	0	0	0
DEV/ANALY	49.6	25.2	27.5	36.9
DEV/COMPUT	37.9	38.6	11.2	2.5
DEV/FACT	0	6.7	0	0.7
ILLUS/ANALY	0	4.8	5.4	2.3
ILLUS/COMPUT	1.2	3.2	4.4	0.7
ILLUS/FACT	0	1.1	0	0
RECAL/ANALY	5.1	2.9	0	7.7
RECAL/COMPUT	0	3.2	8.5	9.7
RECAL/FACT	0	0.5	0.7	1.4

Interactions at the infant age, in the main, concerned the development of analytical skills or computation skills. At the second year junior age, analytical and computation skills were also developed, but in addition emphasis was placed upon the application of computing skills.

Fourth year junior interactions were similar to second year juniors with the addition of application of analytical skills. Secondary age interactions mainly involved analytical work (both the development and application of skills). Very little interaction on computation was observed at this secondary age.

Thus the picture presented is of an infant class where mathematical concepts and computation skills were developed through questioning and informing, with little feedback in terms of responding or reacting to pupils' utterances. At the second year junior age the pattern of work in the infants continued but with the addition of applying the computation skills which were developed earlier. Questioning and informing was again used to some extent, but involvement of pupils appeared higher, if judged by the levels of responding and reacting, as against that of 'informing'. At the fourth year junior age, progress in mathematical learning was evidenced by the development of analytical skills with continued application of computation. By the secondary age, the content appeared to be limited to analytical work with little development or application of computation skills.

Most of the interactions with infants concerned either the development of analytical skills (da) or the development of computational skills (dc). Table 7.35 presents details of the type of interactions between the teacher and infant age children

TABLE 7.35 DESCRIPTION OF THE INTERACTIONS OF TEACHER WITH INFANTS

Speaker and Audience	SOL		RESP		REAC		INFO		Total	%
	da	dc	da	dc	da	dc	da	dc		
BTT	0	2	14	9	0	0	1	3	29	10.4
LTT	3	0	8	5	0	0	2	1	19	6.8
TBT	20	15	2	0	14	11	10	19	91	32.7
TLT	24	9	0	0	10	9	14	10	76	27.3
TCT	2	2	0	0	0	0	2	4	10	3.6
TGT	20	8	0	0	3	0	12	10	53	19.1
n	69	36	24	14	27	20	41	47	278	100

From the table above, it can be readily seen that interactions involving questions from the teacher were directed to individual boys and girls, and also to groups for the purpose of developing analytical skills. Slightly more questions of this kind were directed to girls rather than boys. This might suggest that girls were ahead of boys in mathematical progress, having progressed beyond the development of computation.

Interactions involving the development of computation skills were directed mainly to boys. Information tended to be transmitted from the teacher to individual girls and boys, with slightly more analytical information directed to girls and computation to boys. This result, together with the findings for 'soliciting' described earlier, suggests that girls were ahead of boys in terms of development of mathematical skills at the infant age.

Most interactions involving a speaker 'responding' were from a boy to the teacher in the case of both analytical and computational skills. Girls were much less likely to engage in such interactions. Of 20 solicitings on analytical skills from the teacher to a boy, 14 were responded to, whereas of 24 solicitings from the teacher to a girl, only 8 were responded to. Frequencies of teachers reacting to boys and girls were approximately equal in the case of both analytical and computation interactions.

These findings seem to suggest that while girls and boys are both asked questions about analytical matters, significantly more boys respond. It follows from this that boys would also be likely to get more feedback on analytical skills, whether positive or negative. This result poses the question of whether girls were reluctant to answer questions or whether the teacher gave less time for girls to answer, as suggested in earlier research by Budd Rowe (1974). If girls were reluctant to answer, and if feedback on analytical questions was a factor affecting development of mathematics, then it would seem necessary for girls to be encouraged to respond more than they do to questions posed by the teacher.

Most of the second year junior interactions were for the development of analytical (da) and computational skills (dc), but also for application of computational skills (ac).

TABLE 7.36 DESCRIPTION OF THE INTERACTIONS OF TEACHER WITH 2nd JUNIORS

Speaker	SOL			RESP			REAC			INFO			Total	%
Audience	ac	da	dc	ac	da	dc	ac	da	dc	ac	da	dc		
BTT	3	2	2	2	4	15	0	2	0	0	1	1	32	11.3
LTT	2	3	6	6	6	13	0	0	0	1	2	2	41	14.5
TBT	3	3	14	1	4	2	1	16	9	2	10	11	76	27.0
TLT	7	8	16	2	1	1	8	9	9	13	5	8	87	30.9
TCT	0	4	3	0	0	0	0	2	1	0	2	0	12	4.3
TGT	0	3	12	0	0	0	0	2	3	0	5	9	34	12.1
n	15	23	53	11	15	31	9	31	22	16	25	31	282	100

The majority of 'soliciting' interactions at the second year junior age involved the development of computational skills and were directed to individual girls and boys or to groups. Soliciting interactions were also directed to girls with the purpose of developing analytical skills and applying computation procedures. From table 7.36, junior age girls in the second year received equal amounts of questions on developing computation, and levels of responding as did the boys. However, questions relating to analytical skills were directed to girls rather than boys and responses were proportionately divided between boys and girls. This result is contrary to the suggestion by other writers that girls are involved in interactions involving computation and boys on analytical skills which induces greater cognitive aptitude of boys. However, 'informing' by the teacher was used for developing both analytical skills and computation. These interactions were directed mainly to girls for application of computation skills whereas boys were involved more in the development of computation skills and also development of analytical skills. These results complement the findings for infant age pupils, suggesting that girls progress ahead of boys in mathematical development, being involved in application of computation skills, whereas boys were still at the early development of these skills. The development of computation and analytical skills was evident from the interactions with boys and suggests there may be two levels of achievement of boys - slower learners developing computation, and higher achievers developing analytical skills.

Interactions involving 'reacting' to the development of analytical skills was characteristic of boys rather than girls. Girls received more 'reacting' responses in the application of computation.

Thus the patterns relating to questions and feedback on analytical skills and computation is not as simple as might have been suggested by earlier research. While the evidence at the second year junior age showed boys interacting about analytical skills and girls computation, the computation interactions involve the application of computation skill which appears to be a later stage of mathematical progression than the development of early analytical skills.

At the 4th year junior age most interactions concerned the application of analytical skills (aa), application of computation skills (ac), and development of analytical skills (da).

TABLE 7.37 DESCRIPTION OF THE INTERACTIONS OF TEACHER WITH 4th JUNIORS

Speaker	SOL			RESP			REAC			INFO			Total	%
Audience	aa	ac	da	aa	ac	da	aa	ac	da	aa	ac	da		
BTT	5	3	2	2	8	3	0	0	1	0	1	4	29	13.9
LTT	1	4	6	6	4	4	0	0	0	0	2	4	31	14.9
TBT	5	3	5	1	0	1	6	3	9	6	7	5	51	24.5
TLT	4	6	6	0	3	3	4	2	3	4	10	3	48	23.1
TCT	0	4	5	0	0	0	0	0	2	0	8	8	27	13.0
TGT	1	6	2	0	0	1	0	0	0	0	10	2	22	10.6
n	16	26	26	9	15	12	10	5	15	10	38	26	208	100

Soliciting from the teacher was directed to both girls and boys for applying analytical skills. However, at this age boys 'solicited' the teacher more often than girls i.e. boys were more likely to ask the teacher a question. Questions relating to application of computational skills, however, were directed mainly to girls or groups. Girls solicited more questions on the development of analytical skills. The teacher addressed the whole class on questions about the application of computation and the development of analytical skills. Although both girls and boys were asked questions related to application of analytical skills, more girls responded. While more girls received questions about application of computation, it was the boys who responded more frequently than girls.

The teacher gave more information to boys about application of analytical skills than girls, whereas information relating to application of computation was given to all pupils. Information for the development of analytical skills tended to be given in a whole class situation, and more class interactions took place at this age than previously. From infant to fourth year juniors there was a steady increase in whole class interaction and a decrease in group interaction..

These results suggest a change in the development of girls and boys in terms of mathematical progress. The teacher dealt with application of analytical skills more often with boys than with girls. Boys asked questions relating to application of analytical skills, but girls asked questions on development of analytical skills. There was no evidence at the fourth year junior age that girls were more reluctant to approach the teacher for help, but there was evidence that teachers direct the attention of boys to analytical skills more often at this age, but directed the attention of girls to computation when offering information.

At the secondary age however, most interactions involved the application (aa) and the development (da) of analytical skills.

TABLE 7.38 DESCRIPTION OF THE INTERACTIONS OF TEACHER WITH SECONDARY AGE PUPILS

Speaker and Audience	SOL aa	SOL da	RESP aa	RESP da	REAC aa	REAC da	INFO aa	INFO da	Total	%
BTT	14	4	6	20	0	0	0	2	46	16.8
LTT	10	3	8	11	0	0	1	0	33	12.1
TBT	7	21	8	2	7	13	15	14	87	31.9
TLT	9	15	4	1	5	4	16	9	63	23.1
TCT	2	15	0	0	0	2	3	15	37	13.6
TGT	0	1	0	0	0	0	2	4	7	2.6
n	42	59	26	34	12	19	37	44	273	100

Most questions from the teacher were addressed to boys with the intention of developing analytical skills. Fewer questions of this kind were directed to girls or to the whole class. Boys and girls asked equal numbers of questions of the teacher regarding application of analytical skills. This result is contrary to the suggestion that girls are reluctant to approach the teacher for help. Both 'responding' and 'reacting' was directed by the teacher to boys when developing analytical skills.

The teacher gave information to both girls and boys equally in application of analytical skills, but when developing analytical skills, interactions were directed more to boys and to the whole class. The increase in class interaction and decline in group exchanges continued the pattern found in tthe fourth year juniors. These results indicate that while boys appeared to catch up with the girls in development of analytical skills, boys received more interactions from the teacher generally, especially for the development of analytical skills. When the teacher introduced new work involving the application of analytical work, s/he tended to proceed by means of whole class interactions which, as suggested earlier, may be found too restrictive by girls who appear to prefer a freer style of teaching.

The levels of questions asked of the teacher and responded to by girls and boys was equal for application of analytical skills and therefore it seems likely that the extra attention boys receive and the lower level of individual contact girls get compared to boys affects the attitudes of girls such that they fail to choose to study mathematics at a higher level.

7.31.6 SUMMARY

Sustained conversation was characteristic of the older age groups. Infants experienced rapid 'quick-fire' exchanges with the teacher - some pupils were involved in sustained periods of interaction, but there were many cases where the teacher, with 'Fusspot' pupils who demanded constant attention, coped with these demands by dealing as quickly as possible with individual pupils.

There was some evidence that the teaching styles changed from the infants to the secondary age. At the infant age, most exchanges were with individual pupils or groups of pupils with very little whole class interaction. The level of interactions between the teacher and the whole class monotonically increased throughout the junior age to reach the highest level at the secondary age. Although the teaching style appeared to change, there was no evidence of differential pupil performance on the Bristol Achievement Tests which were discussed in chapter 6. It follows, therefore, that if teaching style does have a causal influence on the underachievement of girls, then this is likely to involve the way in which the style affects attitudes and motivation during the secondary years, particularly at the time when pupils have to choose what subjects to study for public examinations.

The results of the observation of the teachers complement those of the pupil behaviour study. The high level of individual contact between the teacher and pupil on routine matters reflected the incidence of 'Fusspot' pupils at the infant age, although the pattern reflected the behaviour of boys rather than girls. The low level of interaction between pupils and the teacher, characteristic of 'Intermittent Workers', was observed at the second year junior age, slightly more often in the case of girls than of boys. The high levels of class teaching at the secondary age provided opportunities for pupils to behave as 'Solitary Workers' or 'Intermittent Workers'.

Infant pupil-teacher interactions were mainly concerned with task matters but there were also higher levels of 'routine' interactions; more than any other age group. At the second and fourth year junior ages, group work tended to be used for task matters while routine concerns were dealt with on an individual basis. However, at the secondary age, routine matters were mostly dealt with by the teacher addressing the whole class.

At the infant and junior ages, boys received feedback on development of analytical tasks while girls received feedback on application of computation. The results suggest that girls were ahead of boys in terms of mathematical progress. Although girls and boys were both asked questions, boys tended to respond more than girls. This raises the question of whether girls need more time to answer, or whether they are reluctant to answer and therefore need encouragement to do so.

In the fourth year junior classes, boys questioned the teacher more often than girls, but this was not so at the secondary age and therefore does not support the theory that boys become accustomed to talking to the teacher while girls remain reluctant to do so. However, boys in the fourth year juniors and the secondary stage tended to respond to questions more often than girls, and subsequently they received more feedback. At the secondary age, boys received more attention from the teacher in developing analytic skills (although girls were still ahead in attainment), but new work on application of analytical skills was more often presented to the whole class. The attitudes of girls may, therefore, be adversely affected, given that girls do not appear to respond favourably to formal class teaching. Boys were more successful at getting a response from the teacher than were girls, even though both sexes were asked equal numbers of questions. The matter of mathematical content is not a simple one. While girls were involved in interactions about computation, it was in the application of computation rather than its development, which was a later stage of mathematical progression than the development of analytical skills.

Boys tended to receive more negative feedback on behaviour than girls, offering support for the suggestion that boys become accustomed to negative feedback and attribute failure to their lack of effort and success to their ability.

There was some evidence that male and female teachers behaved differently towards the sexes, but it was noted that the sample of male and female teachers in the study were not matched and therefore results could not be taken as conclusive.

It appears, therefore, that at every age, girls and boys were both questioned equally about mathematics, but boys answered and therefore received the extra feedback and attention as reported in the research literature. There is a need, therefore, to investigate attitudes and motivation of pupils, as it seems likely that the underachievement of girls may be influenced to some extent by girls' poor attitudes or lack of confidence preventing them from choosing to study mathematics to high levels of attainment.

CHAPTER 8

THE STUDY OF THE INFLUENCE OF ATTITUDES ON PUPIL PERFORMANCE.

The study of mathematical performance in tests, described in chapter 5, reported that gender differences were limited to a few specific classes only, and limited also to certain mathematical concept areas. Gender differences on mathematics achievement measures was not, therefore, a general finding. Error analysis of omitted responses of girls and boys suggested 'fear of failure', as described by Dweck and Bush (1976), may occur sometime between the 2nd and 4th year junior ages. The sudden occurrence of this 'fear of failure' is likely to be evident by a change in children's attitudes towards mathematics.

Even though this 'fear of failure' may be apparent from the evidence presented in this chapter, the observation study of pupil behaviour in the classroom failed to find support for the theory that girls were less confident in approaching the teacher for help in mathematics.

Given that few gender differences were found in mathematical performance or in behaviour of secondary age pupils, then the reason for many girls failing to choose to study mathematics to a high level of achievement could be related to their attitudes and, perhaps, other external factors which are related to attitudes. The present chapter investigates attitudes of pupils, parents and teachers and examines their influence on pupils' mathematical performance. The main questions investigated were as follows:

1. Do boys have higher positive attitudes towards mathematics than girls?
2. In mathematics do pupils perceive teachers to have a more positive attitude towards boys than girls?

3. Do parental attitudes affect pupil performance in mathematics?

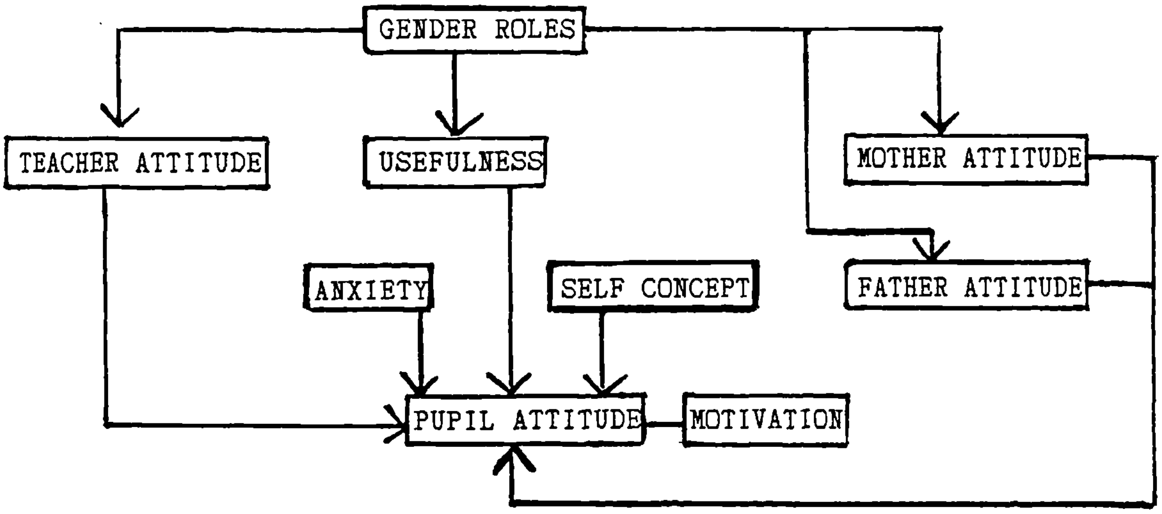
4. Do attitudes reflect mathematical performance in terms of achievement level?

8.1 Introduction

The word 'attitude' has been used liberally by researchers yet several meanings can be attached to this term. Attitudes cannot be observed in the same way, for example, that behaviour can, and therefore the definition of the term is problematic. In order to prevent ambiguity of meaning in interpretation of research results, there is a need, therefore, for each study to offer it's own definition.

In the present study, the term ATTITUDE was used to represent a complex concept which is multi-dimensional. The main dimensions involve 1) motivation which depends on seeing the task as relevant and interesting, 2) self-concept which is the value placed by a person on one's own confidence to perform a task successfully, and 3) anxiety which induces changes in the body such that quality of cognitive performance is affected in an adverse manner.

Influencing these three dimensions are several external factors, such as parental attitudes and teacher attitudes. In the present study the definition of attitudes incorporates the pupil's perception of their parent's attitudes towards mathematics, their perception of the teacher's attitude towards mathematics, the pupil's evaluation of the usefulness of mathematics for their own future, and the pupil's view of the appropriateness of mathematics for both girls and boys alike. The definition of 'attitude' used in the present study is represented in diagrammatic form below:



Although attitudes themselves are not observable, they are presumed to exist because their effects are observable. As they are not observable, then the only way in which they can be measured is by use of psychometric instruments. However, as Elig and Frieze (1979) pointed out, design of such instruments is problematic as they may themselves contain aspects which, unknowingly, have some influence on the way the subject responds.

Most instruments used in the past in an attempt to measure attitudes have consisted of lengthy questionnaires. Other instruments have been based on indirect methods with the intention of getting at a deeper level of attitudes than questionnaires can, given that questionnaires are open to 'fake' answers. Some methods have been based on fantasy where the subject is required to 'tell a story' or to discuss a picture. In this method, the subject has to use his/her own attitudes and experiences in order to respond, and it was anticipated that the result would give an insight into deeper levels of thought.

Indirect methods rely on the subject being naive about the true purpose of the task. Interpretation of the results can be difficult and the validity is often open to debate. One criticism has been that responses may be purely imaginative and not relate to the self in any way. For example Clarke (1973) commented on the use of projective techniques to measure achievement motivation and stated that the poor reliability and validity associated with projective techniques renders the method suspect when predicting student academic performance. But if responses are only imaginative then one would not expect the same response to occur in more than a few children. Thus if similar responses were to be made by many children, then this must reflect how the children feel or how they consider the world expects them to feel. Mitchell (1961) asserted that self-report measures seemed slightly better than projective methods in predicting academic performance. However, self-report tests may lead people to give 'expected' or 'ideal' responses whereas projective tests should be less susceptible to this type of error. Clarke (1969) concluded that Mukherje's unpublished Sentence Completion Test seemed to offer the most promising results.

Researchers, in various fields of study, have attempted to assess the attitudes of certain groups of the population. As mentioned above, the most usual method used has been the questionnaire, and great care has always been taken to ensure the questionnaires were clear, unambiguous and workable while the design sought to minimise the possible occurrence of errors either because of the subjects response or through the researcher's inaccurate marking of scripts. For young children, however, with limited reading and comprehension skills, and a short attention span, wordy questionnaires would seem inappropriate.

Another method of measuring attitudes has been the use of in-depth interviews. In an investigation of suitability of the interview method, Sturgess (1980) reported that interviewing was not precise enough and could not overcome a feeling by those interviewed of being 'got at'.

The present study involving the investigation of attitudes of young children considered all the above mentioned methods of assessing attitudes before taking the following factors into account when determining the type of instrument to be used:

1. primary age children have low levels of reading achievement and vocabulary which renders wordy methods generally unsuitable. Visual methods would be more likely to convey meaning to young children.
2. Young children soon lose their motivation to work on one task and therefore the instrument used should be quick to administer.
3. To be useful as a measuring instrument the method should be capable of being reliably analysed.

For the present study an approach using visual materials with a limit on the need for use of language was finally selected to measure pupil attitudes. To overcome some of the criticisms of projective methods, the results in the present study were classified and coded to produce an objective measure which could be compared with results from other sources, such as observed behaviour. The method of measuring attitudes was innovative and in order to compare it with other methods for ease of use, suitability and quality of response, the secondary age students, who had higher levels of language skills, were also given a questionnaire based on a five-point Likert Scale.

8.2 Procedure

8.21 THE STUDY OF THE SECONDARY AGE PUPILS

8.21.1 THE INSTRUMENT - PILOT STUDY

The students were asked to respond, on a five-point scale, to a number of statements about mathematics, which were selected on the results of a pilot study.

Using statements adapted from various American studies on attitudes towards mathematics, 9 sub-tests were constructed each consisting of 40 statements using the scale Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (A). The 9 tests contained statements referring to nine dimensions and external factors which emerged from the earlier discussion of the definition of attitude for the present study.

1. Motivation and enjoyment
2. Usefulness of mathematics
3. Concept of mother's attitude
4. Concept of father's attitude
5. Concept of teacher's attitude
6. Mathematics as a male domain
7. Pupil's self-concept
8. Anxiety
9. Attitude towards success in mathematics

Questions were drafted so that there were equal numbers of questions requiring positive and negative response to indicate a favourable attitude score. The questions were incorporated into the questionnaire, in a random fashion, to prevent the pupil from discerning a 'pattern' and responding to all questions at one end of the scale.

The sub-tests were administered in such a way that two tests, selected randomly, were completed by each pupil. Ten classes were involved in the pilot study. None of these classes was then involved in the main study.

Each item response was awarded a score between -2 and +2 according to the response from Strongly Disagree to Strongly Agree on positive attitude items and from Strongly Agree to Strongly Disagree on the negative attitude items. A total score for each pupil was obtained by adding the item scores. The responses of the highest scoring 15 per cent and the lowest scoring 15 per cent of pupils for each sub-test was selected for an item analysis. The items with the largest differences between the top scorers and the bottom scorers were taken to be the best discriminators for the purpose of the present study. From these best discriminators, two items requiring a positive response and two items requiring a negative response were selected for the final questionnaire. From the nine sub-tests, therefore, a final questionnaire of 36 items resulted. A copy of the final version of the questionnaire is presented in Appendix 5.

8.21.2 ADMINISTRATION

During the Spring term of the year of study the questionnaire was administered to all pupils in the secondary age classes involved in the study. The pupils were requested, by their teacher, to complete the questionnaire and to hand it in when completed. It was stated that the replies would be treated as confidential and not examined by the teacher. From the 250 questionnaires distributed, 116 replies were received, 48 from girls, 57 from boys, and 11 with the pupil gender not stated.

8.21.3 STATISTICS

1. For each item on the questionnaire general frequencies were obtained to derive the number of pupils obtaining each of the scores from -2 to +2.

2. T-tests on each of the 36 items of the questionnaire were used to test for differences in the responses according to pupil gender and teacher gender. The direction of differences between the means had been predicted in the present study and therefore a one-tailed test was appropriate.
3. The item totals for the nine sub-categories of the attitude test were also calculated. A chi-square test was used to analyse the responses for differences relating to pupil gender, school background, catchment area, and teacher gender.

8.21.4 RESULTS

Table 8.1 presents the general frequencies for each item on the questionnaire.

The results appeared to show that the majority of pupils agreed that mathematics is important for their future lives - 68 disagreed with the statement that mathematics is not needed for a future career, 69 disagreed that mathematics can be forgotten after leaving school, and 65 disagreed that their father thinks the child has no need for mathematics. Similarly, on the items requiring a positive response, 67 strongly agreed that mathematics is useful, while 52 agreed that mathematics will be used a lot in the daily adult life.

TABLE 8.1 FREQUENCIES OF RESPONSES TO EACH ITEM OF THE ATTITUDE QUESTIONNAIRE

	SA -2	A -1	N 0	D +1	SD +2
I do as little in maths as possible	0	5	19	62	30
I'm just no good at mathematics	3	18	26	46	23
When a woman has to solve a maths problem it is feminine to ask for help	2	11	56	22	25
My maths teacher makes maths seem boring	11	17	32	41	15
I don't need maths for my future career	2	2	20	24	68
I would feel embarrassed to get top marks in a maths test	4	11	10	38	53
My mother would never discuss a maths problem with me	12	8	12	40	44
Boys have a natural ability for maths, girls don't	6	6	20	27	57
My progress in maths is unimportant to my father	10	3	18	31	54
I'm a nervous wreck during a maths test	21	19	22	38	16
I get out of doing maths whenever possible	5	12	17	56	26
I try and try but maths still seems very hard for me	10	23	25	46	12
My maths teacher never praises me when I do good work	13	21	27	42	13
Maths can be forgotten when we leave school	3	5	7	32	69
My progress in maths is unimportant to my mother	13	8	15	35	45
I would hate to be top of the class in maths	10	3	14	36	53
My father thinks I have no need for maths	3	3	18	27	65
When I hear the word maths, I have a feeling of dislike	14	18	35	34	15

	SD -2	D 1	N 0	A +1	SA +2
My father is very interested in maths	10	23	31	23	29
My mother has strongly encouraged me to do well in maths	3	14	14	40	45
I'd be proud to get top marks in a maths test	1	2	10	41	62
Maths is enjoyable and stimulating to me	11	26	46	27	6
Maths is very useful	3	1	10	35	67
My maths teacher makes maths interesting	12	17	38	40	9
I feel quite at ease with a maths problem	5	16	60	33	2
I am quite good at working out maths problems	8	28	36	39	5
I feel at ease doing maths	8	23	39	40	6
My father has encouraged me to study more maths	6	18	25	40	27
Women are just as good as maths teachers as men are	5	1	19	33	58
My mother thinks that maths is one of the most important subjects I have studied	3	8	28	40	37
I shall use maths a lot in my daily life as an adult	2	5	35	52	22
My maths teacher knows a lot about maths	6	4	5	39	62
Girls often do as well or better than boys in maths	6	3	24	41	36
Working maths problems is fun	13	26	28	36	13
I can do my maths homework by myself	5	10	19	61	21
I'd feel proud to score highly in maths	1	2	13	46	54

While there was a general disagreement that girls don't have the natural ability for mathematics but boys do, there was also disagreement that girls do as well or better than boys.

The highest frequency of negative scores related to being a nervous wreck during a mathematics test.

On the positive items, most pupils agreed that they would feel proud to get top marks, and also that their teacher knows a lot about mathematics. The most frequent negative scores appeared to be related to the view of mathematics as fun or interesting.

Two aspects of attitudes are apparent, then, from these results. Firstly, the aspect of usefulness of mathematics with which the majority of pupils agreed. Secondly, the aesthetic value in terms of interest and fun, with most pupils disagreeing to those particular items. It was felt to be particularly important to see if girls and boys responded differently to those items relating to usefulness and to aesthetic value. Results of the analysis using the t-test are presented in table 8.2 and 8.3. Only items which yielded a significant difference ($p < 5\%$) were included. A higher score means a higher positive attitude.

From table 8.2, the items requiring a disagreement in order to exhibit favourable attitudes show that boys had higher positive attitudes towards mathematics than girls (a score of 27.9 compared to 22.5, $p < 0.05$). Taking the items individually, boys scored higher than girls on self-concept of their ability, and on the desire to be top of the class. Girls, however, scored more negatively on the item relating to nervousness in mathematics tests ($p < 0.005$) and also appeared to demonstrate less confidence in finding mathematics easy ($p < 0.018$).

TABLE 8.2 MEAN USEAGE OF CATEGORIES ON THE ATTITUDE QUESTIONNAIRE AND T-TEST SIGNIFICANCES - Strongly Disagree scoring high.

Item	Boys' attitude Means	Girl's attitude Means	Significance p<
TOTAL	27.9	22.5	0.05
I'm just no good at mathematics	0.9	0.08	0.00
Boys have a natural ability for maths, girls don't	0.6	1.60	0.00
I'm a nervous wreck during a maths test	0.4	-0.3	0.005
I try and try but maths still seems very hard for me	0.5	-0.02	0.018
When I hear the word maths I have a feeling of dislike	0.4	-0.20	0.007
I would hate to be top of the class in maths	1.3	0.8	0.033

TABLE 8.3 MEAN USEAGE OF CATEGORIES ON THE ATTITUDE QUESTIONNAIRE AND T-TEST SIGNIFICANCES - Strongly Agree scoring high.

Item	Boys'attitude Mean	Girl's attitude Mean	Significance
I feel quite at ease with a maths problem	0.3	-0.20	0.002
I am quite good at working out maths problems	0.3	-0.30	0.001
I feel at ease doing maths	0.30	-0.10	0.049
Women are just as good as maths teachers as men are	0.90	1.60	0.000
Girls often do as well or better than boys in maths	0.7	1.3	0.001
Working maths problems is fun	0.30	-0.30	0.019
I'd feel proud to score highly in maths	1.4	1.1	0.044

From table 8.3 the significant results all show that boys display a more positive attitude to mathematics than girls, except on the items relating to gender and mathematics when the girls' attitudes were more positive than boys. These results indicate that gender differences existed in relation to self-concept of ability and to the aesthetic value of mathematics, but not to a view of the usefulness of the subject.

These findings are consistent with those of Fennema and Sherman (1978) who reported boys to be more confident in mathematics. However, these researchers suggested that this confidence was evident from the pre-school years and so the results of the study of junior age attitudes may indicate if the confidence found in the secondary study were also in evidence at an earlier age in this study, even though few gender differences in mathematics performance have been found. Meece (1982) suggested that there was a decline in self-concept which precedes the decline in girls' mathematical performance. If this is true, then the junior attitude study should reveal less pronounced gender differences in attitudes than the secondary study.

Fennema and Sherman (1977) also reported that girls did not accept mathematics was a male domain and yet their behaviour was not consistent with this belief. The present study also shows that girls did not accept mathematics as a male domain, but the observation study of pupil behaviour was consistent with that result, unlike the findings of Fennema and Sherman.

Although the literature review identified many studies where a correlation existed between confidence in mathematics and achievement, the analysis of secondary pupil attitudes in this study has failed to find a similar relationship.

It has been suggested earlier in the study that pupils may model themselves on teachers of the same gender as themselves. In this way it was thought that female teachers may convey a lack of confidence in mathematics to girls. If this is so, then the attitudes of girls in classes of female teachers should be more more negative than those in classes of male teachers.

The difference in attitudes of pupils according to teacher gender was investigated by means of t-tests. Table 8.4 presents the results of this analysis. A higher mean score represents a higher positive attitude.

Table 8.4 RESULTS OF THE T-TESTS COMPARING PUPIL ATTITUDES ACCORDING TO THE GENDER OF THEIR TEACHER

Item	Attitude score female teacher	Attitude score of male teacher	t	df	Sig
I do as little in maths as possible (SD high score)	0.76	1.09	-2.03	114	0.04
My maths teacher never praises me when I do good work (SD high score)	-0.24	0.32	-2.24	114	0.03

The above table shows that more pupils of female teachers were likely to agree that they do as little in mathematics as possible than the pupils of a male teacher. Pupils of female teachers agreed also that their teacher never praised good work. The differences in responses to certain items reported above in relation to pupil gender differences do not appear to be linked to the gender of the teacher. There is no support therefore for the view that the teacher acts as a model and by doing so female teachers pass on their lack of confidence and dislike of mathematics. However, this present result refers to secondary age pupils only where the teachers were all specialist mathematicians, and it is likely that the effect of teacher gender would be more evident at the primary age level.

The results discussed so far are based on analysis of individual items on the questionnaire. The items were totalled into the nine sub-categories listed earlier in the present chapter. Using these new totals, the Chi-square test was used to analyse the sub-categories by sex of pupil, school background, catchment area, and teacher gender. Table 8.5 presents the direction of the significant results of the analyses. Full details of the analyses are presented in appendix 5.

TABLE 8.5 SIGNIFICANT DIFFERENCES IN ATTITUDE SCORES IN THE SUB-CATEGORIES OF THE QUESTIONNAIRE.

	Pupil		Background		Area		Teacher	
	Boy	Girl	Wc	Mix	Rur	Sub	fem	male
Self-concept (SC)	+	-	-	+				
Conc. of mother (cm)			-	-				
Conc. of father (cf)			-	-				
Enjoyment (enj)	+	-	-	-				
Low anxiety (anx)	+	-	-	-				
Att. toward success in maths (am)	+	-	-	-			+	-
Usefulness of maths (um)	-	-	-	-				
Conc. of teacher (ct)			-	+				
Sex equality (se)	-	+	-	+				
TOTAL	+	-	-	+				

(Where + represents higher scores than expected by chance
- represents lower scores than expected by chance
Significance is taken at 5% level)

The above results suggest that boys responded to the questionnaire in a more positive way than girls in the sub-categories of self-concept, enjoyment, and attitude towards mathematics per se. Boys also appeared to display less anxiety. These findings suggest that while performance on the tests did not discriminate between girls and boys, the attitudes held by the pupils do, with boys displaying a more positive attitude. It may be true, therefore, that girls, who appear to have lower self-concept, display more anxiety, and get less enjoyment from studying mathematics, do not, for these reasons, choose to study mathematics to a higher level even though they have similar abilities to boys.

More girls than boys expressed a favourable attitude to equality of the sexes in mathematics. As no differences in pupil behaviour emerged from the observational study, it appears that girls' view of mathematics, as a male domain, is unlikely to be a factor affecting the decision to choose to study mathematics at a high level.

Table 8.5 shows that pupils from a mixed social class area had higher attitude scores in self-concept, concept of teacher and sex equality than pupils with working class backgrounds. This finding suggests that differences in attitudes between the different pupil genders may be influenced to some extent by the social background from which they come. If social background does affect attitudes, then it may be that the main influence is on the level of achievement to which the pupil aspires. Section 8.25, therefore, of the present chapter investigates the aspiration levels of pupils in terms of future careers.

8.21.5 SUMMARY

In the secondary pupil attitude study, the majority of pupils, both girls and boys agreed that mathematics was useful for their future lives. The results appeared to confirm some of the previous findings of research studies i.e. that boys have a higher self-concept and general attitude to mathematics and less anxiety than girls. There was some evidence that home background was an influence on pupil attitudes too, with mixed social class areas displaying a higher self-concept, more positive concept of the teacher, sex equality and higher total score than working class areas. However, from the overall frequencies of responses to individual items, all of the items with the exception of item 9 had a higher percentage of pupils giving a positive response than a negative response even though the pilot study had attempted to select good discriminating items. It could be that the method of distribution and collection of the questionnaire scripts resulted in a sample of students who were biased towards the positive end i.e that the replies received tended to be from pupils with a positive attitude and motivation towards mathematics. If this was the case, then an improved procedure of handing out and collecting in the completed questionnaires would be necessary in any future investigations. Another possible explanation could be that the pupils were giving the ideal or expected response as reported by Clarke (1973). If this was the case, then the method of questionnaire for measuring attitudes has been unsuitable for the purpose of the present study.

Many of the theories which relate to the influence of attitudes on mathematical performance, suggest a decline in attitudes over the primary to the secondary age years. The following section presents the investigation of attitudes in junior age children.

8.22 THE STUDY OF THE JUNIOR PUPIL ATTITUDES

8.22.1 THE INSTRUMENT

The measurement of attitudes was discussed in section 8.1. To assess attitudes of young children in the present study, the following aspects were taken into consideration:

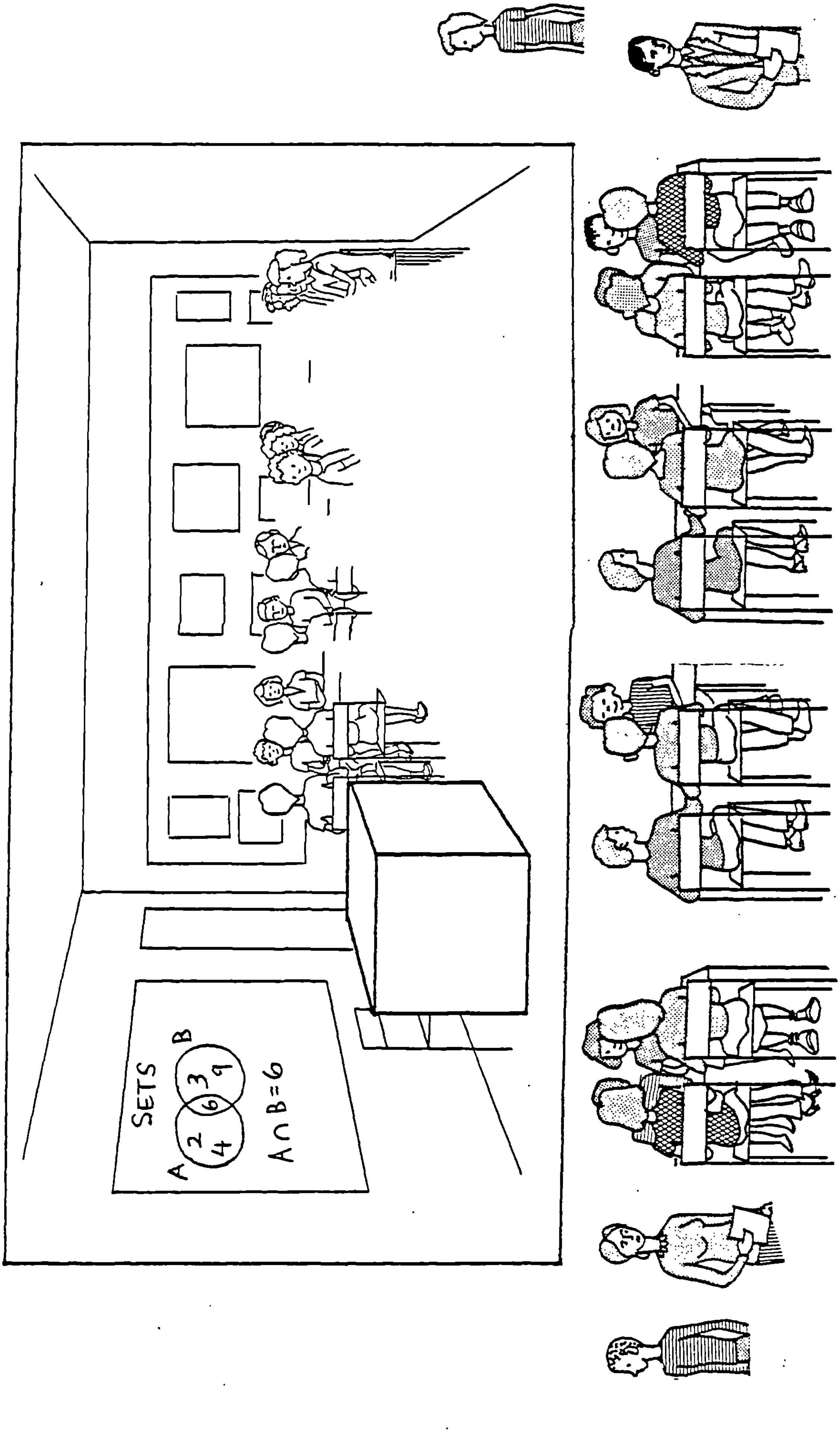


Figure 8.1

a) Visual items were likely to convey more meaning to primary age children owing to the limitations in language skills as a young age.

b) It was important that the instrument was quick and easy to complete in order to avoid any great loss of motivation.

c) The data from the instrument had to be in a form that was capable of being analysed.

In an attempt to fulfill the above requirements, an innovative method using cartoon drawings was devised. A cartoon drawing was required which portrayed a classroom situation during a mathematics lesson. To be pertinent to the present study it was important that the gender of the teacher and gender of the pupils in the foreground of the drawing could vary. A background of a classroom showing mathematics on the blackboard was drawn. Different gender groups of pupils and teacher were drawn as separate cartoons and cut out so that they could be placed on the background as required (see figure 8.1).

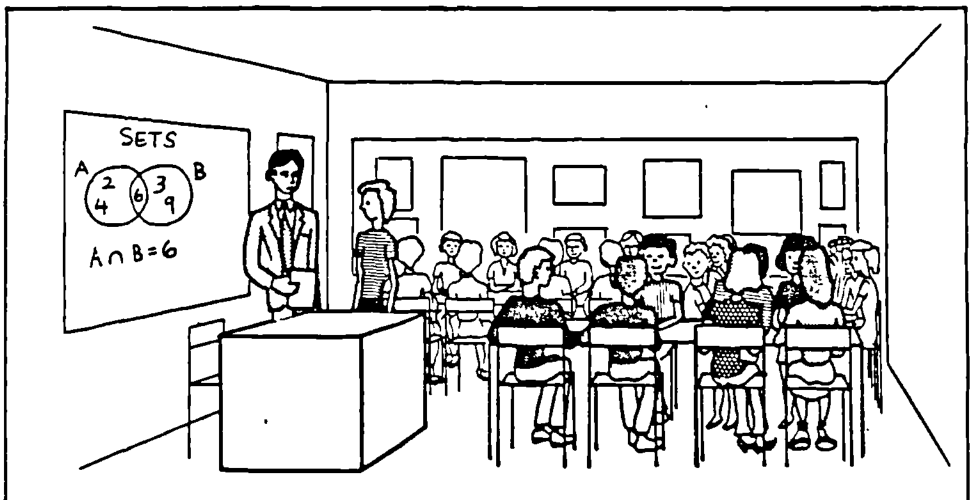


Figure 8.2

It was possible to compose pictures with the teacher sitting with a group, standing in front of the class alone, or standing with one or more pupils as if in a queue. The required compositions were each photographed and then an electronic stencil made from these photographs to enable multiple copies of each cartoon to be made. Figure 8.2 shows one such cartoon. Details of the 16 possible combinations of teacher and pupils in the pictures are presented in appendix 5. A pilot study was undertaken to evaluate different approaches of eliciting a response from the children.

8.22.2 THE PILOT STUDY

Section 8.1 discussed several indirect methods of attempting to derive people's attitudes. A selection of these methods were used with the cartoons in the pilot study and are described below:

1. BALLOONS. The pupils were required to look carefully at the picture and using sticky paper balloons write down the speech of two people in the cartoon, showing clearly who was speaking.

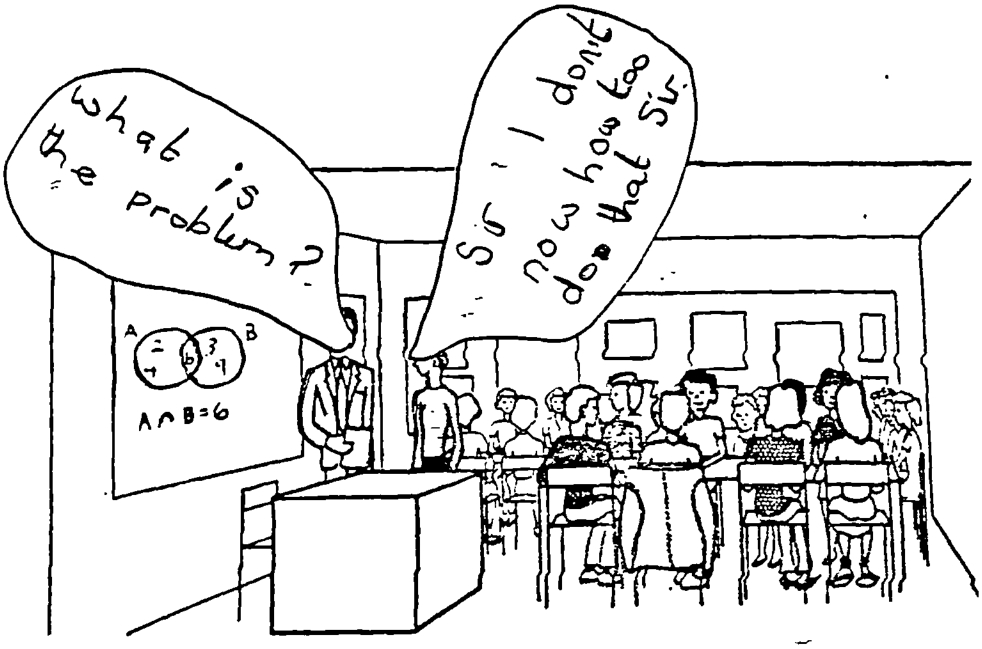
2. WRITE A STORY. The pupils were required to look at the cartoon picture and write a story about the scene.

3. LIMITED SENTENCES. Three sentences were started e.g. 'one of the girls is saying ...' and the pupils were required to look at the picture before completing the three sentences.

4. LONG SENTENCES. This consisted of ten items containing some information about the scene in the cartoon picture followed by an incomplete sentence requiring the pupil's response. e.g. 'A girl has done her work well. A boy is saying to her ....'. A girl is saying to her ....'

The methods were piloted using pupils from two classes of 1st/2nd and 3/4th year pupils who were not involved in the main study. Cartoons and methods of response were selected randomly and distributed by the class teacher one to each pupil. Examples of responses were inspected for suitability of analysis for the purposes of the present study.

BALLOONS



BALLOONS

In the picture, two people are speaking. Using the balloons write in what you think the people are saying and stick the balloons onto the picture, showing clearly who is speaking. Put number one on the balloon showing who is speaking first.

The responses were limited by the amount of writing that would fit into the paper balloons. As the children's writing tended to be big in some cases, very little information was gathered from this method. Teachers found the balloons tended to fall onto the floor so administration caused some problems for the teacher.

STORIES

WRITE A STORY

This is some work on imagination. You will see a picture of a classroom. Look at the picture and write a story about it. Tell what has led up to the scene shown in the picture and what is happening now. What are the thoughts and feelings of the people in the picture ? What will happen next ?

Since it is work on imagination, be sure to tell us a story and not just describe the picture. You will have five minutes to write the story. If you use names, write the names onto the picture to show who is who.

NAME ________________ CLASS ________________

The class room with children in the class
are trying to lern how to do somes.
They feel nerves and skared incase
they get it wrong to imagin about there work.
and they are trying

The responses were interesting and could be classified into descriptive categories e.g. expression of anxiety. The number of words in each story ranged form 33 to 93 and so analysis was difficult. Because of the limitations for the children regarding their reading/vocabulary/writing skills this method was considered unsuitable for the purpose of the present study.

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LIMITED SENTENCES

LIMITED SENTENCES

Look at the picture and then complete the following sentences :-

1. One of the girls is saying ..is..it..play..time..yet.......
2. One of the boys is saying ..miss..can..I..go..toylat.......
3. The teacher is saying .....Stop...talkng..paul.........

LIMITED SENTENCES

Look at the picture and then complete the following sentences :-

1. One of the girls is saying ..they..are...adds..........
2. One of the boys is saying ..they..are....Not..ard..
3. The teacher is saying .....the.are......ese..........

Most pupils were able to complete these sentences and the responses of the pupils could be classified into descriptive categories. In many cases the sentences were taken as sequential in a conversation.

LONG SENTENCES

1. A boy has been messing about instead of doing his work.
   The teacher is saying " JUSt....get...on....with..your...work."

2. A girl has been messing about instead of doing her work.
   The teacher is saying " 'Never...mind...about.....this...work is easy the effort is what counts!'

3. A girl has all of her work right. The teacher is saying "Very...good"..

4. A boy has all of his work right. The teacher is saying "Well...done"..

5. A boy has all of his work wrong. The teacher is saying "Disgracefull!"

6. A girl has all of her work wrong. The teacher is saying "I'm..amazed."

7. A girl has done her work well. A boy is saying to her "Show..off"...
   A girl is saying to her "I...wish.....I....was....you..............

8. A boy has done his work well. A girl is saying to him "I...Can..do.... all that!"
   A boy is saying to him "brains....strikes...again!"....................

9. A girl has done her work badly. A boy is saying to her "Girls...are.... always brainless."
   A girl is saying to her "..Bad....luck"...............................

10. A boy has done his work badly. A boy is saying to him "I....Could...do.. all that work right."
    A girl is saying to him "I...know...you....couldn't....do...it"......

The younger age children and those with reading difficulty had problems with the amount of language on these long sentences. The older children had few problems and responses were suitable for classifying into descriptive categories.

As a result of studying the responses from the pilot study, it was finally decided to use the short three limited sentences for the younger junior age range and both the short and the longer sentence versions for the older junior age range. The responses to the cartoon sentences were inspected and categorised to describe the content of the response. A list of the classifications is presented in the following section.

8.22.3 THE MAIN STUDY

SHORT AND LONG CARTOON QUESTIONNAIRES

The 16 versions of the cartoon were distributed in a random fashion, one cartoon and one limited sentence response sheet being given by the class teacher to each child. There were 8 second year junior classes and 8 fourth year junior classes to receive the cartoons, and the teachers were able to administer them when time allowed during normal lesson periods. The fourth year junior children were also given a long sentence response sheet. The responses to the sentences were then coded according to the following classifications:

1. Inform or reply about routine matters e.g. here's a rubber
2. Enquire about routine matter e.g. can I have the rubber
3. Inform or reply - non-task routine
4. Related to difficulty/dislike of task
5. Enquire - non-relevant e.g. to go to the toilet
6. Praise behaviour
7. Related to ease/liking or completion of task
8. Provide non-factual information - task related
9. Corrective - related to behaviour
10. Ask for factual information - task
11. Provide factual information - task
12. Praise task work
13. Corrective - related to task
14. Other - task related
15. Ask for non-factual information - task
16. Corrective on routine/nastiness/scorn

A full list of example responses within each category is presented in appendix 5.

8.22.4 RELIABILITY OF CODING

A random selection of nine long sentence response sheets were coded according to the above schedule. One week later they were again coded and the number of agreements and non-agreements taken as a measure of reliability of coding. Out of a total of 126 codings, agreement was on 112 giving a reliability of 0.9.

8.22.5 STATISTICS

1. General frequencies of response within each coding category were obtained.
2. The Chi square test was used to compare the different cartoon compositions, in relation to gender of teacher and pupils, with the different responses to the unfinished sentences.
3. Chi-square was also used to compare responses according to pupil gender, achievement level, age of pupil, school background and teacher gender.

8.22.6 RESULTS - LIMITED SENTENCE CARTOON

The categories of responses made by the children were not significantly different according to whether the cartoons characterised a female teacher or a male teacher, or whether the pupils in the foreground were depicted as all female or all male pupils or a mixture of both. It may be that the sentences, by starting as 'one of the girls is saying...', 'one of the boys is saying...' and 'the teacher is saying ...' forces the pupil to consider the cartoon as a general classroom scene, with the pupils in the foreground being just part of the whole scene rather than a prominent part. The majority of pupils did, however, refer to mathematics in at least one part of their responses and the cartoon does seem, therefore to have conveyed the scene of a mathematics lesson.

As the compositions of the cartoons did not appear to affect the frequency of response types made by the pupils, the scripts from each cartoon were aggregated for further analysis. The frequencies of type of response to the three incompleted sentences are presented in table 8.6.

TABLE 8.6 FREQUENCIES OF EACH CATEGORY OF RESPONSE TO THE LIMITED SENTENCES

CODE		SENTENCE 1	SENTENCE 2	SENTENCE 3
1	Inform Rout.	16	18	17
2	Enquire Rout.	24	8	1
3	Inform non-task Rout.	15	25	3
4	Difficulty/dislike	63	53	0
5	Enquire non-task	62	71	1
6	Praise Behaviour	0	1	1
7	Ease/liking	30	46	1
8	Give non-fact. info task	10	17	73
9	Corrective - beh.	8	23	204
10	Ask fact. info - task	64	24	27
11	Give fact.info - task	33	32	5
12	Praise task work	3	3	23
13	Corrective - task	9	12	5
14	Other - task related	8	12	3
15	Ask fact.info - task	35	24	7
16	Nastiness/scorn	6	17	0
	N	386	386	386

SENTENCE 1 'One of the girls is saying....'

Most of the responses to sentence 1 referred to difficulty/dislike of mathematics (63), asking a non-task question (62), or asking for factual information related to the task (64). The non-task questions tended to relate to out of school activities such as 'Are you going to the party?', or to time-wasting strategies such as 'Can I go to the toilet?' and 'Is it playtime yet?' Asking for factual information tended to be of the type 'Can I copy you?' and 'What does that mean?' Typical examples of these responses are presented below.

1. One of the girls is saying ..I cant do this sum"..................

1. One of the girls is saying can I go toilet please....

1. One of the girls is saying ..How do we do this work?

SENTENCE 2 'One of the boys is saying....'

Most of the responses to sentence 2 were similar to those of sentence 1 and referred to difficulty/dislike (53), and to asking a non-task question (71). However, many responses were also related to ease/liking of mathematics (46) such as 'I know the answer to this', rather than asking for factual information. Some example responses are presented below.

2. One of the boys is saying .I do not no my Mathematics

2. One of the boys is saying .."Ah I can it easy"........................

SENTENCE 3 'The teacher is saying.....'

Most of the responses to the third sentence referred to giving non-factual information about the task (73) or to corrective measures for behavioural matters (204). One teacher in the study reported that he was surprised and disappointed to read his pupil's responses as he had actively attempted to prevent being viewed as a discipline keeper. However, that pupils responded to the incomplete sentence in that particular way may be a reflection of the holding of stereotypical views rather than of the treatment and interactions which have been experienced by the pupil within the classroom. Indeed, the results appear to add credence to the cartoon method as a projective instrument for encouraging the subjects to project their inner thoughts and feelings. Given, then, that this method of measuring pupil attitudes has provided evidence of pupils holding stereotypical views, then the results are particularly interesting in that stereotypes were so clearly defined at the junior age. If the view of the teacher as a disciplinarian are so strongly formed in the primary age, then it follows that it is possible for gender stereotypes to be firmly held too. Some example responses to sentence 3 are presented below.

1. One of the girls is saying Happy... Birthday.
2. One of the boys is saying ..Thank..you..........
3. The teacher is saying Shut..up..................

3. The teacher is saying .....Stop.talking..you..can't.work.when.you.are

3. The teacher is saying I..will.tell..you...a..storie.....

The question now arises as to whether the responses, which suggest the holding of stereotypical views, are similar at the younger 2nd year junior age to those of the older 4th year junior children. The differences between these two ages is investigated in the following section.

AGE DIFFERENCES

Table 8.7 presents the percentage frequency of use of each category for the different age groups

TABLE 8.7 PERCENTAGE FREQUENCY OF RESPONSE TYPES OF 2ND AND 4TH YEAR JUNIORS TO EACH SENTENCE

CODE		SENTENCE 1		SENTENCE 2		SENTENCE 3	
		2Jnr	4Jnr	2Jnr	4Jnr	2Jnr	4Jnr
1	Inform Rout.	5.4	3.2	5.4	4.1	4.2	4.6
2	Enquire Rout.	6.5	6.0	3.0	1.4	0.0	0.5
3	Inform non-task Rout.	4.2	3.7	9.5	4.1	1.8	0.0
4	Difficulty/dislike	14.3	17.9	9.5	17.0	0.0	0.0
5	Enquire non-task	21.4	11.9	21.4	16.1	0.6	0.0
6	Praise Behaviour	0.0	0.0	0.6	0.0	0.6	0.0
7	Ease/liking	4.8	10.1	11.3	12.4	0.0	0.5
8	Give non-fact. info task	3.0	2.3	1.2	6.9	16.7	20.6
9	Corrective - beh.	2.4	1.8	5.4	6.4	52.4	53.2
10	Ask fact. info - task	14.3	18.3	4.8	7.3	7.1	6.9
11	Give fact.info - task	7.1	9.6	7.7	8.7	6.0	4.6
12	Praise task work	0.6	0.9	0.0	1.4	8.3	4.1
13	Corrective - task	3.0	1.8	2.4	3.7	0.0	2.3
14	Other - task related	4.2	0.5	4.2	2.3	1.2	0.5
15	Ask non-fact.info -task	6.5	11.0	7.1	5.5	1.2	2.3
16	Nastiness/scorn	2.4	0.9	6.5	2.8	0.0	0.0
	N	168	218	168	218	168	218

The Chi-square test on the effects of age yielded a significant result for sentence 1 ($\chi^2 = 23.00$, df=14, $p \leq 0.06$) and sentence 2 ($\chi^2 = 28.14$, df=15, $p \leq 0.02$) but not sentence 3. The categories in which 2nd and 4th year juniors responded differently are listed below:

Sentence 1 'one of the girls is saying...'

2nd Jnr	4th Jnr
Enquire non-task	Difficulty/dislike Ease/liking Ask factual info. - task Ask non-factual info - task

The younger pupils tended to respond with the girl being engaged in non-task conversation, whereas fourth year children were more concerned with task matters including difficulty and ease of mathematics.

Sentence 2 'One of the boys is saying.....'

2nd Jnr	4th Jnr
Inform non-task Rout.	Difficulty/dislike
Enquire non-task	Give non-fact. info task
Nastiness/scorn	Ask fact. info - task

From the responses to the 'boy' sentence, it was evident that the younger pupils wrote non-task conversation as they had done to the 'girl' sentence, but also included nastiness and scorn such as 'Ha ha, you boys are dunces'. The nastiness and scorn suggests that the children have a perception of gender which is competitive. Nastiness and scorn was characteristic of the 2nd year juniors and therefore the acknowledgement of gender as an influencing factor in the classroom was evident at quite an early age. The fourth year pupils again responded with task-related talk. These results do, therefore, suggest a change in emphasis of thought between 2nd and 4th year juniors where the content of responses changed from non-task to task-related matters. This change coincided with the change found in the study of errors in which it was reported that if Dweck's 'fear of failure' existed, then at the second year junior level it was in arithmetic laws and space, while at the fourth year junior level it was number and reasoning. The change also coincided with the increase in the amount of whole class teaching which was employed. It may be that the move towards a more formal style of teaching in mathematics led to a change in focus of attention in the children, but it could equally be that the change in focus of attention led to the need for the teacher to employ different teaching strategies. The reasons for the change must remain conjecture as they cannot be determined from the evidence so far presented. However, the change in teaching style, change in focus of thought on the Limited Sentence instrument, and the change in mathematical areas in which girls make more errors than boys, all suggest that the time between the 2nd and 4th year junior ages is crucial to the development of girls as mathematical thinkers.

For sentence 3, 'the teacher is saying...', no differences by age reached significance. Indeed, over 50% of all pupils at both the second and fourth year junior ages responded with the teacher being corrective about behaviour. It appears, then, that most pupils viewed the teacher as a disciplinarian even though the observation study of the teacher's behaviour, in chapter 7, reported discipline to account for less than 4% of all interactions. This result clearly illustrates that teachers do convey 'messages' to their pupils by means of their own behaviour, and without this behaviour being particularly great in frequency. The theory of the present study, that small differences accumulate over the primary years and manifest at the secondary age is, therefore, supported by the above results.

The gender of the teacher in the cartoon failed to have differential influence on pupil responses, and the effect of the pupil's own class teacher on response is discussed later in this chapter.

Researchers have, in the past, suggested that children from family backgrounds described as 'working-class' put less emphasis on academic task matters than children with more affluent home backgrounds. If this is true, then, from the results related to age described above, it would be expected that school background as described in the present study would yield significant differences in type of response to the Limited Sentence instrument. The effect of school background is investigated in the following section.

SOCIO-ECONOMIC BACKGROUND

TABLE 8.8 PERCENTAGE FREQUENCY OF RESPONSE TYPES OF PUPILS FROM DIFFERENT SCHOOL BACKGROUNDS

CODE		SENTENCE 1			SENTENCE 2			SENTENCE 3		
		Mid.	Work.	Mix.	Mid.	Work.	Mix.	Mid.	Work.	Mix.
1	Inform Rout.	4,6	6,5	3,4	5,6	0,0	5,2	5,6	6,5	3,4
2	Enquire Rout.	4,6	4,3	7,3	1,9	2,2	2,2	0,0	0,0	0,4
3	Inform non-task Rout.	1,9	6,5	4,3	2,8	21,7	5,2	0,9	2,2	0,4
4	Difficulty/dislike	19,4	13,0	15,5	19,4	8,7	12,1	0,0	0,0	0,0
5	Enquire non-task	5,6	23,9	19,4	11,1	26,1	20,3	0,9	0,0	0,0
6	Praise Behaviour	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,4
7	Ease/liking	13,0	6,5	5,6	15,7	13,0	9,9	0,9	0,0	0,0
8	Give non-fact. info task	3,7	2,2	2,2	4,6	2,2	4,7	18,5	13,0	20,3
9	Corrective - beh.	4,6	0,0	1,3	7,4	2,2	6,0	43,5	65,2	54,7
10	Ask fact. info - task	11,1	21,7	18,1	9,3	6,5	4,7	7,4	6,5	6,9
11	Give fact.info - task	10,2	8,7	7,8	10,2	4,3	8,2	10,2	2,2	3,4
12	Praise task work	1,9	0,0	0,4	0,0	0,0	1,3	5,6	2,2	6,9
13	Corrective - task	2,8	0,0	2,6	1,9	2,2	3,9	0,0	2,2	1,7
14	Other - task related	6,5	0,0	0,4	6,5	2,2	1,7	2,8	0,0	0,0
15	Ask non-fact.info -task	10,2	4,3	9,5	0,9	8,7	8,2	3,7	0,0	1,3
16	Nastiness/scorn	0,0	2,2	2,2	2,8	0,0	6,0	0,0	0,0	0;0
	N	108	46	232	108	46	232	108	46	232

The Chi-square test on the effects of school background yielded a significant result for sentence 1 (χ^2 = 51.85, df=28, p<0.004) and sentence 2 (χ^2 = 58.97, df=30, p<0.001). While the coding categories above are specific and well defined, the effect of school background on children's responses to the Limited Sentences may be made clearer by considering the categories listed above as being in three broad headings - routine, task, and behaviour. A chi-square test was used to investigate whether there was a tendency for girls and boys from different socio-economic backgrounds to respond under one heading more than another. Table 8.9 presents the results.

TABLE 8.9 FREQUENCY OF USAGE OF THE CATEGORIES RELATED TO ROUTINE, TASK AND BEHAVIOUR BY PUPILS FROM DIFFERENT SOCIO-ECONOMIC BACKGROUNDS

CATEGORY	SENTENCE 1			SENTENCE 2			SENTENCE 3		
	Mid.	Work.	Mix.	Mid.	Work.	Mix.	Mid.	Work.	Mix.
Routine	18	19	80	23	23	76	8	4	10
Task	85	26	144	74	22	127	53	12	94
Behaviour	5	1	8	11	1	29	47	30	128
N	108	46	232	108	46	232	108	46	232
Sig.		0.007			0.003			0.05	

From table 8.9 most 'middle class' and 'mixed class' pupils responded with talk related to task matters for both sentence 1 and sentence 2. 'Working class' pupils, however, tended to respond by referring both to routine and to task matters. There are several reasons that may account for this finding but it may be that 'working class' pupils put less emphasis on task than children from other soci-economic backgrounds, or that they view school in a wider sense than pure academic.

The results reported in this chapter so far, suggest that the pupil's age and socio-economic background influences the way pupils focus their attention when responding to the Limited Sentence instrument. Socio-economic background has been reported, by many researchers, to correlate with academic performance of the children and therefore the effect of achievement level on the types of response to the attitude instrument is investigated in the next section.

ACHIEVEMENT LEVEL

The achievement levels gained from the Bristol tests was recorded for those pupils who were involved in the observational study of pupil behaviour. Because of the relatively large number of coding categories for the Limited Sentence instrument, there were insufficient numbers of responses within each category to enable a chi-square test to be reliable. Frequencies of responses using the more global classifications of routine, task and behaviour were recorded and chi-square statistics used for the analysis. The results are presented in table 8.10 below.

TABLE 8.10 FREQUENCIES OF USEAGE OF ROUTINE, TASK AND BEHAVIOUR CATEGORIES BY HIGH, MIDDLE AND LOW ACHIEVER PUPILS

	Sentence 1			Sentence 2			Sentence 3			
	Hi	Mid	Low	Hi	Mid	Low	Hi	Mid	Low	Total
Routine	8	11	4	9	8	9	2	0	2	53
Task	17	11	13	15	11	9	8	8	5	97
Beh.	3	1	2	4	4	1	18	15	12	60
N	28	23	19	28	23	19	28	23	19	210
χ^2	4.02			2.05			2.43			
df	4			4			4			
Sig.	NS			NS			NS			

Differences between the three achievement levels failed to reach significance. This result suggests, then, that differences in type of response in the broad headings of routine, task, and behaviour were due more to the age of the pupil and their socio-economic background than to their mathematical achievement level. Thus it is possible that girls, who had similar performance levels in the Bristol tests, have a different focus in their attitudes towards mathematics than boys do, perhaps due to external influences. This different focus is evident from as early as the 2nd year junior age and may subsequently affect the pupil's view of the importance of mathematics and also their choice of study in later years. What these external factors are, have not been determined but the possibility that parent and teacher attitudes exert an influence upon some of these external factors is investigated later in the present chapter, immediately following the investigation of the responses in relation to pupil gender.

PUPIL GENDER

Table 8.11 presents the percentage frequencies of response type for boys and girls.

TABLE 8.11 PERCENTAGE FREQUENCY OF RESPONSE TYPES OF BOYS AND GIRLS TO EACH LIMITED SENTENCE

CODE		SENTENCE 1		SENTENCE 2		SENTENCE 3	
		Girl	Boy	Girl	Boy	Girl	Boy
1	Inform Rout.	1.0	7.7	4.4	5.0	2.9	6.1
2	Enquire Rout.	4.9	7.7	2.4	1.7	0.5	0.0
3	Inform non-task Rout.	4.9	2.8	6.8	6.1	1.0	0.6
4	Difficulty/dislike	16.1	16.6	13.7	13.8	0.0	0.0
5	Enquire non-task .	17.6	14.4	17.6	19.3	0.5	0.0
6	Praise Behaviour	0.0	0.0	0.5	0.0	0.5	0.0
7	Ease/liking	5.9	9.9	11.7	12.2	0.0	0.6
8	Give non-fact. inro task	2.4	2.8	4.9	3.9	20.5	17.1
9	Corrective - beh.	2.0	2.2	5.9	6.1	50.2	55.8
10	Ask fact. info - task	21.0	11.6	7.8	4.4	8.3	5.5
11	Give fact.info - task	6.8	10.5	7.3	9.4	6.3	3.9
12	Praise task work	0.5	1.1	0.5	1.1	4.9	7.2
13	Corrective - task	3.4	1.1	4.9	1.1	2.0	0.6
14	Other - task related	2.4	1.7	2.4	3.9	1.0	0.6
15	Ask fact.info - task	9.8	8.3	7.3	5.0	1.5	2.2
16	Nastiness/scorn	1.5	1.7	2.0	7.2	0.0	0.0
	N	205	181	205	181	205	181

The chi-square test on the effects of pupil gender yielded a significant result for sentence 1 only, with χ^2 = 25.5, df=14 p<0.03). The categories in which boys and girls responded differently are listed below

Sentence 1 'One of the girls is saying .....'

Boys	Girls
Inform Routine	Inform Non-task
Enquire Routine	Enquire Non-task
Ease/liking	Ask factual information - task
Give factual info. - task	

Boys responded by suggesting that the girl engages in some talk about routine matters whereas girls responded with non-task topics of conversation. While boys saw 'the girl' as giving factual information, girls reported 'her' to be asking for factual information. These differences do, therefore, appear to show a discrepency in perception of each other's views. The gender differences reported suggest that either girls and boys have different views of classroom interaction uppermost in their minds, or boys have a different concept of what a girl is thinking or talking about than girls do. In order to investigate this it was necessary to establish whether girls and boys tended to respond to the whole instrument with conversation concerning one of the three broad headings - routine, task, and behaviour. A chi-square test was used for the analysis. Table 8.12 presents the results.

TABLE 8.12 FREQUENCY OF USAGE OF THE CATEGORIES RELATED TO ROUTINE, TASK AND BEHAVIOUR BY BOYS AND GIRLS

	SENTENCE 1		SENTENCE 2		SENTENCE 3	
Category	Boy	Girl	Boy	Girl	Boy	Girl
Routine	59	58	58	64	12	10
Task	115	140	99	124	68	91
Behaviour	7	7	24	17	101	104
N	181	205	181	205	181	205
Sig.	NS		NS		NS	

Differences between boys' and girl' responses failed to reach significance. It appears therefore that the differences found between the genders in the responses to sentence 1 are likely to be a difference in the concept of what girls talk about. Boys would, in this particular instance, view a girl as talking about routine matters or ease of the task more than girls do. Girls tended to view their own gender in a less positive light by talking off-task and asking for factual information.

To complete the investigation of responses to the limited sentence method, the effect of teacher gender is discussed in the following section.

TEACHER GENDER

Table 8.13 presents the percentage frequencies of response categories according to the gender of the class teacher.

TABLE 8.13 PERCENTAGE FREQUENCY OF USEAGE OF RESPONSE CATEGORIES BY PUPIL ACCORDING TO TEACHER GENDER

CODE		SENTENCE 1		SENTENCE 2		SENTENCE 3	
		Fem	Male	Fem	Male	Fem	Male
1	Inform Rout.	6.3	2.0	6.3	3.1	5.8	3.1
2	Enquire Rout.	5.8	6.6	2.1	2.0	0.5	0.0
3	Inform non-task Rout.	4.2	3.6	5.8	7.1	1.1	0.5
4	Difficulty/dislike	18.9	13.8	11.6	15.8	0.0	0.0
5	Enquire non-task	17.4	14.8	16.8	19.9	0.5	0.0
6	Praise Behaviour			0.5	0.0	0.5	0.0
7	Ease/liking	6.8	8.7	13.2	10.7	0.0	0.5
8	Give non-fact. info task	2.1	3.1	2.6	6.1	17.9	19.9
9	Corrective - beh.	2.6	1.5	7.4	4.6	50.5	55.1
10	Ask fact. info - task	13.2	19.9	5.8	6.6	7.9	6.1
11	Give fact.info - task	5.8	11.2	6.8	9.7	6.3	4.1
12	Praise task work	0.5	1.0	1.6	0.0	5.3	6.6
13	Corrective - task	3.7	1.0	3.2	3.1	0.5	2.0
14	Other - task related	1.6	2.6	2.1	4.1	0.5	1.0
15	Ask non-fact.info -task	8.4	9.7	6.8	5.6	2.6	1.0
16	Nastiness/scorn	2.6	0.5	7.4	1.5	0.0	0.0
	N	190	196	190	196	190	196

The Chi-square test on the effects of teacher gender failed to yield any significant differences. However, when the categories listed above are reformed into three broad headings - routine, task, and behaviour, the chi-square test resulted in one significant result. Table 8.14 presents the results.

TABLE 8.14 FREQUENCY OF USAGE OF THE CATEGORIES RELATED TO ROUTINE, TASK AND BEHAVIOUR BY PUPILS ACCORDING TO TEACHER GENDER

	SENTENCE 1		SENTENCE 2		SENTENCE 3	
Category	Fem	Male	Fem	Male	Fem	Male
Routine	64	53	59	63	15	7
Task	116	139	102	121	78	81
Behaviour	10	4	29	12	97	108
N	190	196	190	196	190	196
Sig.	NS		0.01		NS	

Sentence 2 'One of the boys is saying ....'

Pupils in classes of male teachers made more responses related to task than pupils of female teachers, while the pupils of female teachers made more responses concerned with behaviour. From the observation study of teacher interactions with pupils reported in chapter 7, pupils of female teachers were more concerned with behaviour than those of male teachers, and this finding appears to be echoed in the responses of pupils to sentence 2 of the attitude instrument as above. However, the observational study also reported pupils of female teachers to engage in interactions about task, and this finding is not echoed in the results above. There is insufficient evidence, therefore, that the responses made by pupils to the Limited Sentence method is related to the immediate experience they get in the classroom. The *responses may, more* importantly, reflect the view of the pupils after an accumulation of different experiences in and out of school up to the time of the study.

8.22.7 SUMMARY

Some interesting responses resulted from this study and various dimensions have been extracted from the data. Generally the categories of responses fall into the global categories of routine, task, and behaviour. Differences were found within these related to age of pupil, school background, and teacher gender. Most pupils responded to suggest the teacher is seen as a discipline controller, even when the class teacher had been trying to avoid this perception but there was some evidence that the responses were the result of accumulative experiences, or stereotypical views, rather than what is happening in their present classroom. The results support the use of the cartoon method as an effective projective instrument to obtain information on pupils' inner thoughts and feelings.

The view of the teacher as a disciplinarian was formed by the 2nd year junior age and the possibility exists that perception of gender stereotypes is evident by the 2nd year junior age too.

Younger pupils responded using non-task talk but older pupils focussed on task matters. This result coincides with the change in errors and amount of class teaching, and therefore the period from 2nd to 4th year juniors is crucial to develop girls as mathematical thinkers.

Boys see girls in a different way than girls see themselves. The focus of girls may limit their freedom to choose to study mathematics in later years.

Socio-economic factors also appear to affect the views of boys and girls with working class background pupils being less task orientated than those of middle and mixed class backgrounds.

The findings reported above were interpreted from the analysis of the short Limited Sentence attitude instrument. The longer version of the attitude instrument was completed by the same 4th year juniors as the Limited Sentence instrument, and analysis of the long version is important to determine the reliability of the shorter method as a means of assessing children's attitudes. This will be dealt with in the following section.

8.22.8 RESULTS - MULTIPLE LIMITED SENTENCE CARTOON

No significant differences were found between responses to different cartoon compositions and therefore the responses to all of the cartoons were combined for further analysis. The frequencies of type of response to the version of Multiple Limited sentences are presented in table 8.15.

TABLE 8.15 FREQUENCIES OF RESPONSE TO EACH SENTENCE OF THE MULTIPLE LIMITED SENTENCE METHOD

CODE	SENTENCE 1	2	3	4	5	6	7_1	7_2	8_1	8_2	9_1	9_2	10_1	10_2	TOT
1,Inform Rout,	0	0	1	2	0	1	0	1	1	2	1	1	1	1	12
2,Enquire Rout,	0	0	0	0	0	0	0	4	2	4	1	1	4	3	19
3,Inform non-task Rout,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4,Difficulty/dislike	0	0	0	0	0	0	19	40	15	20	0	3	3	1	101
5,Enquire non-task	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3
6,Praise Behaviour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,Ease/liking	0	0	0	0	0	1	8	9	7	13	7	16	11	12	84
8,Give non-fact, info task	8	8	1	9	71	68	1	4	3	6	12	18	24	23	256
9,Corrective - beh	172	167	0	0	11	11	0	1	1	0	2	2	2	1	370
10 Ask fact, info - task	0	0	0	0	0	0	20	21	14	21	0	3	0	1	80
11,Give fact,info - task	0	0	0	0	1	0	0	0	0	0	0	0	2	0	3
12,Praise task work	0	0	177	167	0	3	40	55	60	51	1	3	1	0	558
13,Corrective - task	0	1	0	1	93	88	4	4	4	5	40	26	32	32	330
14,Other - task related	1	1	1	1	0	0	2	4	5	3	3	2	3	1	27
15,Ask non-fact,info -task	0	1	2	2	5	7	3	4	1	4	0	5	2	6	42
16,Nastiness/scorn	1	4	0	0	0	0	85	26	67	43	88	22	40	69	445
17,Comradeship	0	0	0	0	1	3	0	9	2	8	27	80	57	31	218
N = 182															2548

The first and second sentences tended to include expressions suggesting the teacher was taking corrective measures for behaviour (172 and 167).

> 1. A boy has been messing about instead of doing his work.
> The teacher is saying " Stop messing about hurry and get on with your work."
>
> 2. A girl has been messing about instead of doing her work.
> The teacher is saying " be a good girl and geton with your work please."

This finding is similar to that of the shorter Limited Sentence method where the teacher tended to be viewed as a discipline keeper regardless of the pupils' experiences within their present classroom.

Sentence 3 and 4 described a situation in which good work had been produced by the children. The responses to 'the teacher said...' were almost totally about praising task work (177 and 167). The observational study of behaviour in chapter 7 failed to find frequent use of praise to reward task work and therefore the result from the cartoon responses appears to suggest that the children responded to what they felt would be a suitable response rather than to what actually happens in the classroom of their most recent experience.

3. A girl has all of her work right. The teacher is saying .Very..Good 10/10

4. A boy has all of his work right. The teacher is saying you can.do.... Something right at last

Sentence 5 and 6 described a situation in which poor work had been produced by the children. The responses to 'the teacher said ....' were of the type giving non-factual information about the task, or giving negative feedback about work to the children (93 and 88).

5. A boy has all of his work wrong. The teacher is saying "Do..it..again..and this time concentrate!"

6. A girl has all of her work wrong. The teacher is saying "..Think..again..and read the exersise properly."

Sentence 7 contained two unfinished sentences each requiring a response. The sentence described a situation in which a girl had done her work well, and one response was required to 'A boy said to her...'. The responses to this unfinished sentence were mainly of the type 'nastiness/scorn' (86), and some 'praising of task work' (40). The second unfinished sentence required a response to 'A girl said to her...'. The level of 'praise' type of response was quite high (55), but the second most frequent type was 'difficulty/dislike'.

> 7. A girl has done her work well. A boy is saying to her ..Smart..alec...
>
> A girl is saying to her ..very...well..done I got mine right

Sentence 8 also required two responses, one that a boy said and one a girl, but the situation was of a boy doing work well. For the girl's response, most pupils chose to respond with 'nastiness/scorn' (68) and 'praise' (60) which was less nastiness and more praise than with the sentence 7 of a girl doing good work. For the response of a boy, the most frequent types of response were also 'nastiness' (43) and 'praise' (51) but these levels were rather lower than for the first part of the sentence.

> 8. A boy has done his work well. A girl is saying to him ...creep............
>
> A boy is saying to him ..."Good kid"..

It appears from the results above that pupils tend to view boys as being more likely to express nastiness to girls than girls are to boys. Praise was expressed towards the boy's good work more than to the girl's good work. If pupils do perceive girls to have less praise and more ridicule than boys then the actual behaviour in the classroom is not necessarily the influence on pupil's choice to study mathematics, but the perceptions may be. The reasons for such perceptions are unclear but may be the result of teacher and parent attitudes which are investigated later in the present chapter.

Sentence 9 suggested that a girl had done her work badly. Boys were reported to express nastiness (88) with some corrective to task expressions (40) and slight feelings of comradeship (27). Responses for the girl were mainly 'comradeship' (80) with lower levels of 'corrective task' (26) and 'nastiness' (28).

> 9. A girl has done her work badly. A boy is saying to her .Ah! Ah! Poor thing.
>
> A girl is saying to her ..Shutup! And leave her alone................

Sentence 10 suggested that a boy had done his work badly. The response of a boys was expressed as 'comradeship' (57), 'nastiness' (41), or 'corrective to task' (32). Girls responses however were expressed mainly as 'nastiness' (99) with some 'comradeship' (31) and 'corrective to task' (32).

> 10. A boy has done his work badly. A boy is saying to him .never..mind.... I will help you
>
> A girl is saying to him .1/10....ha..I..got....10/10.:..................

These results provide some evidence of competition between the sexes with same sex pupils showing comradeship and opposite sex pupils showing nastiness/scorn regardless of whether the pupil described had worked well or badly.

The results described above are based on data of all the fourth year junior pupils. It may be that these reported differences between girls and boys may vary according to the achievement level of the pupils. To investigate whether pupils of different achievement levels responded differently to each other the data was reformed into four broad categories of behaviour, task, routine, and comradeship.

ACHIEVEMENT

The results of the chi-square test on the response categories according to achievement level are presented in table 8.16.

TABLE 8.16 FREQUENCIES OF USAGE OF CATEGORIES BY PUPIL ACHIEVEMENT LEVEL

	Achievement Level											
	1				2				3			
Category	Beh	Tsk	Rout	Com	Beh	Tsk	Rout	Com	Beh	Tsk	Rout	Com
Sentence												
1	14	0	0	0	12	0	0	0	7	1	0	0
2	12	2	0	0	12	0	0	0	8	0	0	0
3	0	14	0	0	0	12	0	0	0	8	0	0
4	0	14	0	0	0	12	0	0	0	8	0	0
5	0	14	0	0	1	11	0	0	1	7	0	0
6	1	13	0	0	2	9	0	1	0	8	0	0
7_1	6	8	0	0	6	6	0	0	5	3	0	0
7_2	5	7	0	0	2	9	1	0	1	6	0	1
8_1	6	7	1	0	6	6	0	0	4	4	0	0
8_2	4	7	0	2	2	9	1	0	3	4	0	1
9_1	8	5	0	0	7	3	1	1	4	3	0	1
9_2	5	4	0	5	2	3	0	7	1	5	0	2
10_1	6	3	1	4	7	3	2	0	0	6	0	2
10_2	6	3	2	3	4	5	1	2	4	2	1	1
TOTAL	73	99	4	14	63	88	6	11	38	65	1	8
N		190					168				112	

χ^2 on totals (excluding routine) =0.97, df=4, NS

Achievement appears to have had no effect on the type of response given to the Multiple Limited Sentence method and further analysis was therefore not warranted.

The shorter version of the method, described earlier in the present chapter, reported that boys tended to have a different view of what girls would say than what girls do themselves. To investigate this further, the Multiple Limited Sentence method was analysed by pupil gender.

PUPIL GENDER

TABLE 8.17 FREQUENCY USAGE OF CODING CATEGORIES BY GIRLS AND BOYS OVER THE ENTIRE INSTRUMENT

	GIRLS		BOYS		TOTAL
	Freq	%	Freq	%	
1.Inform Rout.	4	0.3	8	0.6	12
2.Enquire Rout.	8	0.7	11	0.8	19
3.Inform non-task Rout.	0	0	0	0	0
4.Difficulty/dislike	63	5.2	38	2.9	101
5.Enquire non-task	0	0	3	0.2	3
6.Praise Behaviour	0	0	0	0	0
7.Ease/liking	42	3.4	42	3.2	84
8.Give non-fact. info task	127	10.4	129	9.7	256
9.Corrective - beh	184	15.1	186	14.0	370
10 Ask fact. info - task	36	3.0	44	3.3	80
11.Give fact.info - task	0	0	3	0.2	2
12.Praise task work	263	21.6	295	22.2	558
13.Corrective - task	153	12.4	177	13.3	330
14.Other - task related	7	0.7	20	1.5	27
15.Ask non-fact.info -task	19	1.7	23	1.7	42
16.Nastiness/scorn	210	17.2	235	17.7	445
17.Comradeship	102	8.3	116	8.7	218
N	1218	100	1330	100	2548

From table 8.17 the total use of each coding category was similar for girls and boys on all categories except category 4. Category 4 referred to difficulty/dislike and girls responsed in this category more often than boys (5.2% compared to 2.8%). This result reflects a more negative attitude of girls towards mathematics and a lack of self confidence which may affect the choice to study mathematics in later years.

Table 8.18 and table 8.19 present the use of the coding categories for each sentence with girls' responses presented separately from boys' responses.

TABLE 8.18 FREQUENCIES OF CATEGORIES FOR EACH SENTENCE FOR GIRLS

CODE	SENTENCE														
	1	2	3	4	5	6	7_1	7_2	8_1	8_2	9_1	9_2	10_1	10_2	TOT
1,Inform Rout,	0	0	0	2	0	0	0	0	0	1	0	0	0	1	4
2,Enquire Rout,	0	0	0	0	0	0	0	2	1	1	1	1	1	1	8
3,Inform non-task Rout,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4, Difficulty/dislike	0	0	0	0	0	0	13	26	9	13	0	1	1	0	63
5,Enquire non-task	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,Praise Behaviour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,Ease/liking	0	0	0	0	0	1	3	2	3	8	4	8	6	7	42
8,Give non-fact, info task	4	2	0	0	35	27	1	2	1	5	8	11	17	14	127
9,Corrective - beh	82	80	0	0	7	10	0	1	0	0	1	2	0	1	184
10 Ask fact, info - task	0	0	0	0	0	0	9	10	4	10	0	2	0	1	36
11, Give fact,info - task	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,Praise task work	0	0	86	85	0	2	18	22	31	17	1	1	0	0	263
13,Corrective - task	0	0	0	0	43	44	2	1	3	1	18	11	15	15	153
14,Other - task related	0	0	0	0	0	0	1	2	1	0	2	0	1	0	7
15,Ask non-fact,info -task	0	1	1	0	2	3	2	1	0	3	0	3	1	2	19
16,Nastiness/scorn	1	4	0	0	0	0	33	14	34	22	43	9	19	27	210
17,Comradeship	0	0	0	0	0	0	0	4	1	6	9	38	26	18	102
N = 87															1218

TABLE 8.19 FREQUENCIES OF CATEGORIES FOR EACH SENTENCE FOR BOYS

CODE	SENTENCE														
	1	2	3	4	5	6	7_1	7_2	8_1	8_2	9_1	9_2	10_1	10_2	TOT
1,Inform Rout,	0	0	1	0	0	1	0	1	1	1	1	1	1	0	8
2,Enquire Rout,	0	0	0	0	0	0	0	2	1	3	0	0	3	2	11
3,Inform non-task Rout,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4, Difficulty/dislike	0	0	0	0	0	0	6	14	6	7	0	2	2	1	38
5,Enquire non-task	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3
6,Praise Behaviour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,Ease/liking	0	0	0	0	0	0	5	7	4	5	3	8	5	5	42
8,Give non-fact, info task	4	6	1	9	36	41	0	2	2	1	4	7	7	9	129
9,Corrective - beh	90	87	0	0	4	1	0	0	1	0	1	0	2	0	186
10 Ask fact, info - task	0	0	0	0	0	0	11	11	11	11	0	1	0	0	44
11, Give fact,info - task	0	0	0	0	1	0	0	0	0	0	0	0	2	0	3
12,Praise task work	0	0	91	82	0	1	22	33	29	34	0	2	1	0	295
13,Corrective - task	0	1	0	1	50	44	2	3	1	4	22	15	17	17	177
14,Other - task related	1	1	1	1	0	0	1	2	4	3	1	2	2	1	20
15,Ask non-fact,info -task	0	0	1	2	3	4	1	3	1	1	0	2	1	4	23
16,Nastiness/scorn	0	0	0	0	0	0	47	12	34	21	45	13	21	42	235
17,Comradeship	0	0	0	0	1	3	0	5	1	2	18	42	31	13	116
N = 95															1330

Sentences 1 to 5 were completed in a similar fashion by girls as by boys. In sentence 6, where 'a girl has done work badly', boys more than girls viewed the teacher as giving non-factual information about the task whereas girls gave more responses of the type 'corrective to behaviour'. Both boys and girls saw the teacher as corrective about the task.

6. A girl has all of her work wrong. The teacher is saying Now you must start again

6. A girl has all of her work wrong. The teacher is saying you was messing Abot

In sentence 7, in which 'a girl has done her work well', boys saw the boy as expressing 'nastiness/scorn' more than girls did, whereas girls more than boys saw the boy as expressing 'difficulty/dislike'. This result suggests a feeling of competitiveness between the sexes.

Boys more than girls saw a girl as expressing praise, thereby a suggestion of comradeship, while girls again responded more than boys with difficulty/dislike expressions.

7. A girl has done her work well. A boy is saying to her I wish mine was right

A girl is saying to her "I didn't get my work right"

Sentence 8 described a boy working well. Both girls and boys answered similarly for the response from a girl, both answering with nastiness or praise expressions. Boys more than girls expressed praise from a boy whereas girls again expressed more difficulty/dislike than boys did.

These results again confirm a feeling of competitiveness between the sexes.

> 8. A boy has done his work well. A girl is saying to him ."Show..off."..
>
> A boy is saying to him ."your...dead..good..at..doing..work".'

Sentence 9 showed no differences between responses from boys and girls, both using nastiness or comradeship expressions.

> 9. A girl has done her work badly. A boy is saying to her .Ha..Im..dibog
>
> A girl is saying to her .."Hard luck".................................

Sentence 10 described a situation in which a boy worked badly. Boys saw the boy's response as comradeship more often than girls did, while girls more than boys suggested the boy was giving non-factual information about the task. Boys more than girls reported the girl to be 'nasty/scornful'.

> 10. A boy has done his work badly. A boy is saying to him .never..mind, I'll Help you
>
> A girl is saying to him ..You..do...and..I'll..tell............

As only the fourth year juniors completed this Multiple Limited Sentence Method, there was insufficient data to enable comparison of socio-economic backgrounds or of teacher gender.

8.22.9 SUMMARY

Responses to the questionnaire suggested that the teacher was viewed as a discipline keeper, a finding reaffirmed by the results of the Short Limited sentences method described earlier.

Pupils, both girls and boys, suggested that boys express more nastiness/scorn to girls than girls do themselves, and that praise from the teacher is more likely to be expressed for a good work by a boy than for good work by a girl. This result suggests that pupils hold false perceptions of teacher behaviour as the observational study of pupil and teacher behaviour reported earlier failed to report this bias of praise for boys.

A feeling of competitiveness between girls and boys, and of comradeship between same sex pupils was strongly evident. These perceptions, while not appearing to affect behaviour and performance in the classroom, may affect choice of study in later years, particularly as there was also some evidence to suggest that girls hold a more negative attitude towards mathematics and a greater lack of self-confidence than boys.

Children tended to respond in ways which were not indicative of their recent classroom experience. This may suggest that children are answering what they feel they are expected to, or answering in stereotypical ways i.e. fake responses, but even if this is true, it seems likely that these fake responses provide insight into the perceptions children hold. These perceptions are likely to affect their future choice of subject for higher level study. The source of these perceptions is unclear, but may be linked in some way to their experience of teacher attitudes and parental influence. These two aspects are investigated in the present chapter.

The results above confirm that pupils are aware of gender but whether the results would be found in other curriculum areas cannot be determined from this study. It would be useful for further research to compare the method used in the present study with different curriculum area content on the blackboard in the cartoons. Most of the questionnaire scrips suggested that the pupils did perceive the situation to be a mathematics lesson and therefore the cartoons were useful as an instrument for setting the scene to which the children had to respond. The grouping of girls and boys, and the presence of a male or female teacher in the cartoons did not affect the type of responses which were given. If the Limited Sentence method was to be useful to teachers to determine which pupils required intervention programmes to modify negative attitudes, then a standard cartoon drawing depicting the appropriate curriculum area may be sufficient.

While the Short Limited Cartoon method was useful to gain information of a large number of children, the longer method was more effective in gaining information regarding gender awareness and negative attitudes of the individual pupil.

The following section investigates teacher attitudes as a possible source of the cause of children's perceptions towards mathematics.

8.23 INVESTIGATION OF TEACHER ATTITUDES

The review of the research in chapter 4 described theories which have suggested the importance of teacher attitudes in their influence on mathematical performance of pupils. According to Newbold (1977), attitudes affect pupil's subject choice in later school years. The results of the attitude questionnaires described earlier suggest that girls and boys perceive teachers, girls, and boys to behave in certain ways, irrespective of the classroom experience they have had. It was suggested that pupils' perceptions must be influenced by external factors of which teacher attitudes may be one. The influence of teacher attitudes on pupils' perceptions may be due to the teacher acting as a model by which, according to Good and Brophy (1971), primary female teachers with a lack of confidence in mathematics transmit negative attitudes to girls but not to boys. Ward (1979) suggested that teachers' lack of confidence is linked to their level of qualifications, but up to now this has been pure conjecture. This section on teacher attitudes investigates the confidence expressed by teachers towards mathematics per se but also to the teaching of mathematics, and compares the results of the attitude questionnaire according to the qualifications and experience of the teachers involved.

8.23.1 THE INSTRUMENT

An instrument was required which would be quick and easy to complete while gathering enough information for the purposes of the study outlined above. The instrument used was one based on an idea by Willcocks (Simon and Willcocks, 1981) who used a questionnaire design requiring the subject to underline relevant words in response to a statement. Willcocks' questionnaire was designed for parents to express any anxieties felt by their son or daughter at the prospect of transferring to a second school. For the present study, the questionnaire was developed such that teachers were required firstly to underline words which described how they themselves felt towards mathematics, and secondly to underline words which described how they felt towards the teaching of mathematics.

The first part of the questionnaire contained words which were related to self-concept, anxiety, motivation, usefulness, and male/female domain. The words used were matched as closely as possible such that a positive word had a matched negative word e.g. failure-successful. The words used on the questionnaire were all taken from longer questionnaire studies on gender differences in attitudes. Table 8.20 presents the list of words from each sub-category.

TABLE 8.20 WORDS USED IN EACH SUBCATEGORY OF THE QUESTIONNAIRE STUDY OF HOW TEACHERS FELT TOWARDS MATHEMATICS.

Self-concept.

ABLE	STRUGGLING	CONFIDENT	DIFFICULT
SMART	FAILURE	SUCCESSFUL	CONFUSED
EASY	ILLOGICAL		

Male-Domain.

FEMININE	MASCULINE

Anxiety.

CALM	ANXIOUS	MATTER-OF-FACT	DISTRESSED
CHEERFUL	SCARED	COMFORTABLE	PANIC
PLACID	WORRY		

Motivation.

DISLIKE	LIKE	HATE	STIMULATED
DISINTERESTED	ENTHUSIASTIC	MUNDANE	CHALLENGE
BORING	FUN		

Usefulness.

HELPFUL	UNIMPORTANT	ESSENTIAL	FORGETTABLE
USEFUL	UNNECESSARY	RELEVANT	WASTE
IMPORTANT	IRRELEVANT		

The second part of the questionnaire related to self-concept, anxiety and motivation in relation to how the teacher felt towards teaching mathematics. The words used are listed in table 8.21.

TABLE 8.21 WORDS USED IN EACH SUBCATEGORY OF THE QUESTIONNAIRE STUDY OF HOW TEACHERS FELT TOWARDS TEACHING MATHEMATICS.

Self-concept

ABLE	STRUGGLING
CONFIDENT	CONFUSED
SUCCESSFUL	FAILURE

Anxiety

CALM	DISTRESSED
MATTER-OF-FACT	ANXIOUS

Motivation

ENTHUSIASTIC	DISLIKE
STIMULATING	MUNDANE
CHALLENGE	UNSURE

8.23.2 PROCEDURE

The words were presented in a *random* order to prevent any pattern of words being perceived by the teacher. A copy of the full questionnaire is presented in Appendix 6.

In addition to the words for underlining, the questionnaire also collected information about the date of the teacher's training, their specialist subject, whether a graduate or not, age group of the teacher, and teacher gender. Provision was also made for the teacher to write any further comments they wished to make.

8.23.3 ADMINISTRATION

One questionnaire was given to all the teachers in each primary school involved in the study, both those who were involved in the observation study and those who were not. At the secondary age, questionnaires were given to all teachers who taught in the mathematics departments. The teachers were requested to complete the questionnaire and to return them at the next observation visit or by post if preferred. The confidentiality of the information was stressed to the teachers, and no names were required to be put on the forms. The heads of the schools were not invited to look at the completed forms so that teachers would not feel constrained in their responses.

8.23.4 STATISTICS

1. General frequencies and standard deviation measures were taken for each variable on the questionnaire.

2. The Chi-squared test and Pearson's R correlation were used to investigate the significance of teaching experience, level of teacher academic achievement, curriculum area of teacher specialism, and teacher gender.

3. While the teacher questionnaire was designed from the basis of several pre-determined sub-categories of words (e.g. self-concept), it was important to the present study to investigate the differential selection of words by male and female teachers. For this investigation a factor analysis was used on all of the questionnaire items.

8.23.5 RESULTS

A total of 44 questionnaires were returned. A summary of the experience of the teachers who responded is presented in table 8.22.

TABLE 8.22 DESCRIPTION OF THE SAMPLE IN TERMS OF EXPERIENCE AND GRADUATE STATUS

Yrs of teaching	$\leq$ 5	6-9	10-14	15+
Graduate	9	1	5	3
Non-graduate	1	6	7	12

$\chi^2 = 14.74$ df=3 sig = 0.002

Most graduate teachers in the study were those with less than five years teaching experience. This link between graduate status and length of teaching experience is illustrative of the relatively recent change in teacher training requirements that teaching should become an all-graduate profession.

Table 8.23 presents the frequencies and standard deviation for each word on the questionnaire over the whole sample.

TABLE 8.23 FREQUENCIES AND STANDARD DEVIATION OF EACH VARIABLE ON THE TEACHER QUESTIONNAIRE RELATING TO HOW THE TEACHER FELT ABOUT MATHEMATICS

VARIABLE	FREQUENCY N=44	STANDARD DEVIATION
DISLIKE	6	0.35
DISINTERESTED	5	0.32
HATE	2	0.21
LIKE	33	0.44
ABLE	17	0.49
CALM	6	0.35
ANXIOUS	12	0.45
CONFIDENT	13	0.46
DISTRESSED	1	0.15
ENTHUSIASTIC	21	0.51
MATTER-OF-FACT	6	0.35
CHEERFUL.	17	0.49
SCARED	2	0.21
STIMULATED	16	0.49
STRUGGLING	5	0.32
SMART	1	0.15
SUCCESSFUL	5	0.32
FAILURE	2	0.21
CONFUSED	2	0.41
ILLOGICAL	2	0.21
COMFORTABLE	13	0.46
PANIC	2	0.21
PLACID	6	0.35
WORRY	7	0.37
HELPFUL	21	0.51
MUNDANE	1	0.15
UNIMPORTANT	1	0.15
ESSENTIAL	36	0.39
USEFUL	26	0.50
UNNECESSARY	1	0.15
RELEVANT	27	0.49
IMPORTANT	33	0.44
IRRELEVANT	0	0.15
FORGETTABLE	4	0.29
FEMININE	1	0.15
UNSURE	5	0.32
MASCULINE	1	0.15
BORING	1	0.15
CHALLENGE	26	0.50
FUN	20	0.50
WASTE	1	0.15
DIFFICULT	12	0.45
EASY	8	0.39

From table 8.23, the words chosen by the majority of teachers to describe how they felt towards mathematics were LIKE (33), ESSENTIAL (36), and

IMPORTANT (33), which are all positive attitude words. The most frequent negative attitude words were ANXIOUS (12), and DIFFICULT(12).

TABLE 8.24 FREQUENCIES AND STANDARD DEVIATION OF EACH VARIABLE ON THE TEACHER QUESTIONNAIRE RELATING TO HOW THE TEACHER FELT ABOUT TEACHING MATHEMATICS

VARIABLE	FREQUENCY N=44	STANDARD DEVIATION
HAPPY	28	0.49
CONFUSED	4	0.29
ENTHUSIASTIC	29	0.48
DISTRESSED	0	
ABLE	24	0.50
CALM	9	0.41
CONFIDENT	17	0.49
STIMULATED	13	0.46
SUCCESSFUL	13	0.46
FAILURE	1	0.15
UNSURE	7	0.37
ANXIOUS	8	0.39
STRUGGLING	3	0.26
DISLIKE	2	0.21
HATE	0	
BORING	0	
FUN	20	0.50
CHALLENGE	32	0.45
MUNDANE	1	0.15

From table 8.24, the words chosen most frequently to describe how the teacher felt about the teaching of mathematics were CHALLENGE (32), ENTHUSIASTIC (29), and HAPPY (28), which were all positive attitude words. No teacher underlined DISTRESSED, HATE, or BORING, but the most frequently used negative attitude word was ANXIOUS (8). This result appears to suggest that teachers generally, while feeling some anxiety, do appear to have positive attitudes towards mathematics and therefore would not be expected to convey a negative attitude to pupils, but maybe a feeling of anxiety. However, the above results are based on the whole sample of teachers whether mathematics specialists or not. Table 8.25

presents the usage of the words by teachers who described themselves as mathematics/science specialists and those with other curriculum areas as their specialism.

TABLE 8.25 PERCENTAGE FREQUENCY OF MATHEMATICS/SCIENCE SPECIALSTS COMPARED TO NON-SPECIALISTS

VARIABLE	% OF SPECIALISTS N=9	% OF NON-SPECIALISTS N=35
DISLIKE	0	17
DISINTERESTED	0	14
HATE	0	6
LIKE	100	69 * p<.05
ABLE	67	31 * p<.05
CALM	33	9
ANXIOUS	33	26
CONFIDENT	78	17 * p<.001
DISTRESSED	0	3
ENTHUSIASTIC	89	37 * p<.01
MATTER-OF-FACT	11	14
CHEERFUL	56	34
SCARED	11	3
STIMULATED	67	29
STRUGGLING	11	11
SMART	0	3
SUCCESSFUL	33	6
FAILURE	0	6
CONFUSED	22	0
ILLOGICAL	0	6
COMFORTABLE	67	20 * p<.01
PANIC	11	3
PLACID	33	9
WORRY	11	17
HELPFUL	67	43
MUNDANE	11	0
UNIMPORTANT	11	0
ESSENTIAL	78	83
USEFUL	67	57
UNNECESSARY	0	3
RELEVANT	67	60
IMPORTANT	78	74
IRRELEVANT	0	0
FORGETTABLE	0	11
FEMININE	0	3
UNSURE	11	11
MASCULINE	11	0
BORING	11	0
CHALLENGE	78	54
FUN	67	40
WASTE	11	0
DIFFICULT	44	23
EASY	22	17

The chi-square test yielded significant differences on five words from the attitude questionnaire relating to attitude to mathematics per se. The word LIKE was underlined by all of the mathematics/science specialists but only 69% of non-specialists. ABLE was chosen more by the specialists (67% compared to 31%), was CONFIDENT (78 compared to 17%), ENTHUSIASTIC (89 and 37%) and COMFORTABLE (67 and 20). Although no significant differences were found in which non-specialists had greater usage than specialists, the words in which the frequencies were greater were negative words such as DISLIKE, DISINTERESTED, HATE, FAILURE, ILLOGICAL, WORRY, and FORGETTABLE.

TABLE 8.26 PERCENTAGE FREQUENCY OF MATHEMATICS/SCIENCE SPECIALSTS COMPARED TO NON-SPECIALISTS ON PART TWO OF THE QUESTIONNAIRE

VARIABLE	% OF SPECIALISTS N=9	% OF NON-SPECIALISTS N=35
HAPPY	67	63
CONFUSED	22	6
ENTHUSIASTIC	89	60
DISTRESSED	0	0
ABLE	89	46 * p<.025
CALM	44	14
CONFIDENT	78	29 * p<.01
STIMULATED	55	51
SUCCESSFUL	67	20 * p<.01
FAILURE	0	3
UNSURE	22	14
ANXIOUS	22	17
STRUGGLING	0	9
DISLIKE	0	6
HATE	0	0
BORING	0	0
FUN	67	40
CHALLENGE	78	71
MUNDANE	0	3

From table 8.26 specialists chose three words significantly more than non-specialists with regard to teaching of mathematics- ABLE (89 compared to 46), CONFIDENT (78 compared to 29), and SUCCESSFUL (6 compared to 20).

FAILURE, UNSURE, and ANXIOUS were the only words chosen more by non-specialists, but the differences did not reach significance. Even so, most non-specialists chose positive words such as HAPPY, ENTHUSIASTIC, and CHALLENGE.

Ward (1979) suggested that teachers' attitudes were dependent on their level of qualification. For this investigation a correlational analysis was used to compare graduate and non-graduate responses to attitude to mathematics per se. Three words produced significant correlations with graduate status - CHALLENGE, HAPPY and ABLE.

CORRELATION RESULTS

TABLE 8.27 SIGNIFICANT CORRELATIONS WITH 'GRADUATE/NON-GRADUATE' STATUS

VARIABLE	PEARSON'S R	SIGNIFICANCE
CHALLENGE	-0.248	0.05 ng
HAPPY	0.245	0.05 g
ABLE	0.295	0.03 g

Non-graduate teachers chose CHALLENGE more than graduates ($p \leqslant .05$) while graduates chose HAPPY ($p \leqslant .05$) and ABLE ($p \leqslant .03$). Choice of HAPPY and ABLE might suggest a greater confidence in graduates but few significant differences were found and therefore provides little support for Ward's assertion.

TABLE 8.28 SIGNIFICANT CORRELATIONS WITH LENGTH OF EXPERIENCE

VARIABLE	PEARSON'S R	SIGNIFICANCE
LIKE	0.27	0.37
ENTHUSIASTIC	0.30	0.02
CHALLENGE	0.32	0.02
CONFIDENT	0.47	0.001
SUCCESSFUL (teaching)	0.28	0.03
CHALLENGE (teaching)	-0.28	0.03

Six words produced significant results. Higher experienced teachers selected LIKE, ENTHUSIASTIC, CHALLENGE, CONFIDENT towards mathematics, and SUCCESSFUL in the teaching of mathemaitcs. Low experience teachers chose CHALLENGE. These differences were investigated further using Chi-squared to test for significant differences according to the years of teaching. Table 8.29 presents the significant results.

CHI SQUARE

TABLE 8.29 CHOICE OF THE VARIABLE 'CONFIDENT' IN TEACHING ACCORDING TO LENGTH OF TEACHING EXPERIENCE

Yrs teaching	≤5	6-9	10-14	15+
%	20	0	33	73
N	10	7	12	15

χ^2 = 13.63 df=3 sig = 0.004

Confidence appears to be highest with teachers of 15+ years experience which might be expected. However, CONFIDENT was also well chosen by newly qualified and 10-14 years experience teachers but less so by teachers with 6-9 years of experience. It may be that after six years of teaching, teachers have enough experience to question their own methods and begin to investigate strategies which are successful leading to a fain in confidence again after 10+ years, perhaps due to involvement on inset courses.

TABLE 8.30 CHOICE OF THE VARIABLE 'CHALLENGE' IN TEACHING ACCORDING TO LENGTH OF TEACHING EXPERIENCE

Yrs teaching	≤5	6-9	10-14	15+
%	100	86	42	73
N	10	7	12	15

χ^2 = 10.18 df=3 sig = 0.017

All newly lower experienced teachers chose the word CHALLENGE. The drop in choice of CHALLENGE came from 10-14 years of experience. The reason for this drop is unclear.

Only one significant chi-square result was obtained in relation to age of teacher and the results are presented in table 8.31.

TABLE 8.31 CHOICE OF THE VARIABLE 'CONFIDENT' IN TEACHING ACCORDING TO AGE OF TEACHER

Age	21-25	26-30	31-35	36-40	41-45	46-50	over 50
%	33	0	25	50	57	67	83
N	3	10	8	6	7	3	6

χ^2 = 14.22 df= 6 sig = 0.027

Confidence increased according to the age of the teacher with the exception of 26-30 year olds. This is likely to be linked to teaching experience which, as discussed above, may be a time of reflection and self-criticism following the first few years of teaching.

Table 8.32 presents the significant correlations according to teacher gender. Five words yielded significant correlations - CONFIDENT, STIMULATED, and FUN with regard to attitude to mathematics, and STIMULATED and CHALLENGE in relation to the teaching of mathematics.

TABLE 8.32 SIGNIFICANT CORRELATIONS WITH TEACHER GENDER

VARIABLE	PEARSON'S R	SIGNIFICANCE
CONFIDENT	0.40	0.00 m
STIMULATED	0.36	0.01 m
FUN	0.30	0.03 m
STIMULATED (teaching)	0.30	0.03 m
CHALLENGE (teaching)	0.26	0.05 m

(where m represents male teachers having made more frequent choice of the word)

The five words listed above were all chosen by male teachers more than female teachers. This result provides some evidence that male teachers more than female teachers have (or perceive they are expected to have) confidence in mathematics. There was no evidence, however, of female teachers having more negative attitudes than males which fails to support the theory that female teachers with negative attitudes act as a model for girls thus conveying negative feelings.

FACTOR ANALYSIS

The teacher questionnaire produced a fairly low response but the data from 44 questionnaires resulted in three factors

FACTOR 1

Disinterested
Hate
Distressed
Smart
Failure
Illogical
Panic
Unnecessary
Irrelevant
Forgettable
Boring
Waste
Failure (teaching)
Mundane (teaching)

FACTOR 2

Like
Confident
Enthusiastic
Cheerful
Stimulated
Challenge
Fun
Enthusiastic (teaching)
Confident (teaching)
-Unsure
-Disinterested
-Anxious
-Dislike

FACTOR 3

Anxious
Confused (teaching)
Unsure (teaching)
Anxious(teaching)
-Happy (teaching)

1. This factor indicated words which were chosen very rarely i.e. a 'Low-used' factor. It is interesting to note that all of the words in this factor were negative attitude words. It may be that teachers were

reluctant to admit to these negative feelings and would be more likely to omit positive attitude words to display a negative attitude rather than to select negative attitude words.

2. The second factor contained words which expressed a positive attitude of confidence, enthusiasm, and a feeling of fun about mathematics leading to confidence and enthusiasm in teaching of it.

3. The third factor expressed anxiety - anxiety about mathematics itself and the teaching of it together with a feeling of being confused and unsure about the teaching of mathematics.

Using the variables on factor 3, anxiety scores were obtained by summing the number of positive factor variables which the teacher had underlined and subtracting the negative factor variables underlined. Table 8.33 presents the frequency of male and female teachers with the scores from -1 to +4. A score of -1 represents a low anxiety score and +4 a high anxiety score.

TABLE 8.33 FREQUENCIES OF MALE AND FEMALE ANXIETY SCORES

Score	-1	0	1	2	3	4	Total
Female Tchr	11	9	2	1	1	2	26
Male Tchr	11	2	2	1	1	0	17
N	22	11	4	2	2	2	43

While two female teachers scored highly on anxiety, chi-squared failed to reach significance and therefore the majority of male and female teachers scored low on the anxiety factor.

Table 8.34 presents the scores of male and female teachers on factor 2, a positive attitude including CONFIDENCE, where the higher positive score represents a more positive attitude.

TABLE 8.34 FREQUENCY OF MALE AND FEMALE ATTITUDE SCORES

Score	-3 to 0	1 - 5	6 - 9	Total
Female	6	15	5	26
Male	3	4	10	17
Total	9	19	15	43

$\chi^2 = 7.47$, df=4, NS

Most female teachers scored between 1 and 5, a moderate attitude score whereas most male teachers scored higher in the 6 - 9 range. Using chi-squared the difference between the scores failed to reach significance. However, the slightly higher scores of male teachers lends some support to the idea of male teachers being more confident and have positive attitudes towards mathematics. However, there is no evidence that most female teachers tend to have negative attitudes which they might convey to girl pupils by acting as a model.

8.23.6 SUMMARY

Graduate teachers tended to be those with low levels of teaching experience which is illustrative of the trend in training to change to an all-graduate profession.

There was some evidence that teachers generally express positive attitutes towards mathematics and teaching of mathematics, but also express a feeling of anxiety. If teacher attitudes do have a detrimental effect on girls more than boys with regard to pupil attitudes, then it must be that girls are affected by a model of anxiety being displayed rather more than boys are.

Some differences in attitudes were found in relation to mathematics specialists and other curriculum specialists. While both groups tended to choose positive attitude words, specialists chose like, able, confident and enthusiastic more than non-specialists. Non-specialists did choose some negative words such as dislike, failure, hate and worry more than the specialists, but the differences failed to reach significance.

No support was found for Ward's assertion that teacher attitudes are dependent on the level of qualification.

Length of teaching experience and age of the teacher appeared to be closely associated, with older and more experienced teachers expressing more confidence and feeling of success. It appears that a lowering of confidence occurs after about 6 years of teaching, perhaps due to a period of reflection and self-appraisal combined with attendance on inset courses, with an increase in confidence after 10 years of teaching

Male teachers were found to express more confidence and feelings of fun and challenge towards mathematics and the teaching of it. However there was no evidence of a negative attitude in females, only a lower attitude than males. There is no evidence, therefore, for the theory that female primary teachers act as a model for girls and convey negative attitudes. While it could be that male teachers convey more positive attitudes to boys, there are generally less male primary teachers than female and would not, therefore, explain the development of pupil gender differences in mathematics performance.

A factor analysis produced a positive attitude factor, and an anxiety factor. When male and female teachers were compared on these factors, both male and female teachers scored low in anxiety, and slightly more male teachers scored a positive attitude although this difference failed to reach significance.

Few significant differences resulted from the above analysis to suggest that teacher attitude has any great influence on pupil attitudes and subsequently performance in mathematics. If teacher attitude is not, therefore one of the important external factors affecting pupil attitude, then parent attitudes may be the more influential external factor. Parent attitudes are investigated in the following section.

8.24 Investigation of Parent Attitudes

The review of the research in chapter 4 described theories which have suggested that pupil academic achievement is influenced in some way by the home. For example, Luchins and Luchins (1980) reported that parental encouragement is more often in evidence for sons than for daughters which is likely to have detrimental effects on the performance of girls in mathematics particularly. Blatchford et al (1985) reported differences in girls' and boys' acquisition of literacy and numeracy skills at the pre-school age which appeared to be linked to the educational level of mothers and other home background influences. The present study has argued that pupil attitudes are affected by external factors so that many pupils, particularly girls, fail to choose to study mathematics to a high level even when their achievement level is satisfactory. Luchins (1981) reported that women see parents as the greatest influence on their mathematical achievement, whereas boys see teachers as the greatest influence on their achievement. The present study failed to provide evidence that teacher attitudes affect one pupil gender more than another but it may be that parent attitudes are a stronger influential external factor on childrens' mathematical achievement.

8.24.1 THE INSTRUMENT

The instrument used to study parent attitudes was similar to the instrument described in 8.23.1 and which was used to investigate teacher attitudes. The instrument was based on an idea by Willcocks (Simon and Willcocks, 1981) and required the parents to underline words, firstly to describe how they felt about mathematics per se, secondly on how they would feel if their child was very bright at mathematics, and thirdly to describe how they perceived their child to feel about mathematics.

The first part of the questionnaire contained words which were related to self-concept, anxiety, motivation, usefulness, and male/female domain. The words used were matched as closely as possible such that each positive word had a matched negative word e.g. successful-failure. The words used for the first part of the questionnaire were exactly the same as those used for the teacher attitude study and are listed in table 8.20 earlier in the present chapter.

The second part of the questionnaire contained words to describe how the parent would feel emotionally if their child was exceptionally bright at mathematics. The words used for this second part of the questionnaire are presented in table 8.35.

TABLE 8.35 WORDS TO DESCRIBE HOW THE PARENT WOULD FEEL IF THEIR CHILD WAS EXCEPTIONALLY BRIGHT AT MATHEMATICS

Marvellous	Embarrassed
Happy	Conspicuous
Proud	Wary
Encourage	Waste
Help	Discourage

The third part of the questionnaire on how the parent perceived the child to feel about mathematics contained words relating to self-concept, anxiety, motivation, and usefulness. The words used are listed in table 8.36.

TABLE 8.36 WORDS TO DESCRIBE HOW THE PARENT PERCEIVED THEIR CHILD TO FEEL ABOUT MATHEMATICS

Child's Self-Concept.		
	SMART	STRUGGLING
	SUCCESSFUL	CONFUSED
	CONFIDENT	FAILURE
	ABLE	ILLOGICAL
Child's Anxiety.		
	CALM	ANXIOUS
	CHEERFUL	SCARED
	MATTER-OF-FACT	DISTRESSED
Child's Motivation.		
	ENTHUSIASTIC	BORING
	CHALLENGE	DISLIKE
	INTERESTED	HATE
Usefulness.		
	USEFUL	UNNECESSARY
	IMPORTANT	FORGETTABLE
	RELEVANT	WASTE

8.24.2 PROCEDURE

The words were presented in random order to reduce the possibility of parents perceiving any pattern of the words. A copy of the full questionnaire is presented in Appendix 6. In addition to the words for underlining, the questionnaire also collected information about the parent's gender, and provision was made for the parent to write any further comments they wished to make.

8.24.3 ADMINISTRATION

Two questionnaires, one for the mother and one the father, were sent to the parents of all the pupils in the classes involved in the study. The questionnaires were given to the pupils to take home with an accompanying letter explaining the purpose of the study. The confidentiality of the information was stressed to the parents and names were not required to be put on the completed forms. Mothers and fathers were requested to complete the forms separately, and discussion could take place only after the questionnaires had been completed. The completed scripts were to be returned to the school by their child.

8.24.4 STATISTICS

1. General frequencies of all the words were obtained.
2. A two-tailed t-test was conducted to test the effects of parent gender, and pupil gender.
3. The chi-squared test was conducted on responses of parents by pupil gender, and to compare age effects.

8.24.5 RESULTS

A total of 365 completed questionnaires were returned of which 197 were completed by fathers and 168 by mothers. Table 8.37 presents the raw frequencies and percentage frequencies for each word on the first part of the questionnaire describing how the parent felt towards mathematics.

TABLE 8.37 FREQUENCY OF WORDS USED TO DESCRIBE HOW THE PARENT FELT TOWARDS MATHEMATICS

Variable	Raw Score	%	Variable	Raw Score	%
DISINTERESTED	18	4.9	WORRY	27	7.4
LIKE	151	41.4	COMFORTABLE	114	31.2
ABLE	124	34.0	ESSENTIAL	247	67.7
STRUGGLING	56	15.3	BORING	15	4.1
CALM	82	22.5	USEFUL	238	65.2
CONFIDENT	99	27.1	MASCULINE	3	0.8
ANXIOUS	39	10.7	UNNECESSARY	1	0.3
FAILURE	22	6.0	WASTE	0	0.0
SCARED	8	2.2	EASY	28	7.7
ENTHUSIASTIC	60	16.4	FUN	61	16.7
ILLOGICAL	3	0.8	IRRELEVANT	3	0.8
SUCCESSFUL	53	14.5	DIFFICULT	43	11.8
CHEERFUL	50	13.7	FEMININE	1	0.3
DISLIKE	38	10.4	IMPORTANT	265	72.6
DISTRESSED	6	1.6	RELEVANT	157	43.0
UNSURE	61	16.7	CHALLENGE	140	38.4
CONFUSED	46	12.6	FORGETTABLE	9	2.5
SMART	14	3.8	HELPFUL	212	58.1
MATTER-OF-FACT	55	15.1	MUNDANE	7	1.9
STIMULATED	45	12.3	UNIMPORTANT	1	0.3
PANIC	13	3.6	PLACID	26	7.1
HATE	13	3.6			
N	365				

From table 8.37 the words most frequently selected by parents to describe how they felt towards mathematics were IMPORTANT (265), ESSENTIAL (247), USEFUL (238), and HELPFUL (212). These words were all positive attitude words. Of the negative attitude words the most frequently selected were UNSURE (61), STRUGGLING (56), CONFUSED (46), and DIFFICULT (43).

This result suggests that most parents perceived mathematics to be an important curriculum area yet only 27% chose the word CONFIDENT and only 15% SUCCESSFUL. While there was a tendency for positive attitude words to be chosen by all parents, those selecting negative attitude words tended to express words associated with their perceived ability to do mathematics - STRUGGLING, CONFUSED, and DIFFICULT. While only 22 expressed FAILURE, 38

DISLIKED the subject and 27 expressed WORRY. Thus it seems that while most parents saw mathematics as useful, they themselves found it difficult and this may be the reason why few parents, when pupils themselves, would have chosen to study mathematics to any great extent. This issue is investigated further by comparing mother and father attitudes separately. The question arisen relates to whether females and males have different perceptions of usefulness and difficulty of mathematics.

Table 8.38 presents the significant results of the t-test on the words from part 1 of the questionnaire.

TABLE 8.38 WORDS FROM THE PARENT QUESTIONNAIRE WHICH WERE SELECTED SIGNIFICANTLY DIFFERENTLY BETWEEN MOTHERS AND FATHERS

WORDS MOTHERS CHOSE MORE THAN FATHERS			WORDS FATHERS CHOSE MORE THAN MOTHERS		
Word	T	Sig	Word	T	Sig
STRUGGLING	5.04	0.000	LIKE	-2.47	0.014
ANXIOUS	4.15	0.000	ABLE	-2.66	0.008
FAILURE	3.18	0.002	CALM	-2.60	0.010
DISLIKE	2.59	0.010	CONFIDENT	-4.72	0.000
UNSURE	5.58	0.000	SUCCESSFUL	-2.89	0.004
CONFUSED	5.30	0.000	COMFORTABLE	-5.03	0.000
WORRY	3.43	0.001			
DIFFICULT	4.26	0.000			

From table 8.38, mothers expressed a more negative attitude than fathers, choosing words related to both anxiety and ability. Fathers, in complete contrast, expressed a more positive attitude choosing words related to liking, ability, and confidence.

To summarise, only a minority of parents selected negative attitude words but of those who did, most were mothers. While many parents selected positive attitude words, fathers more than mothers were willing to express this positive attitude. It may be therefore, that fathers and mothers convey an attitude towards mathematics to their children by acting as a model or by actively encouraging their daughters or sons in stereotypical ways to develop in certain curriculum areas.

Table 8.39 presents the frequencies of words selected by parents to describe how they would feel if their child was exceptionally bright at mathematics.

TABLE 8.39 FREQUENCIES OF WORDS USED BY PARENTS TO DESCRIBE HOW THEY WOULD FEEL IF THEIR CHILD WAS BRIGHT AT MATHEMATICS.

Word	Frequency
MARVELLOUS	164
EMBARRASSED	1
HAPPY	292
CONSPICUOUS	1
PROUD	280
UNSURE	3
WARY	4
ENCOURAGE	298
HELP	193
WASTE	0
DISCOURAGE	0

N=365

From table 8.39 the majority of parents selected positive attitude words with ENCOURAGE being the highest frequency (198) followed by HAPPY (292) and PROUD (280). No differences reached significance on the t-test comparing fathers and mothers, or comparing responses of parents of boys and girls.

Table 8.40 presents the frequencies of words selected to describe how the parents perceived their child to feel towards mathematics.

TABLE 8.40 FREQUENCIES OF WORDS USED TO DESCRIBE HOW THE PARENT PERCEIVED THEIR CHILD FELT ABOUT MATHEMAITCS

Word	Frequency	%	Word	Frequency	%
CALM	122	33.4	CONFUSED	34	9.3
ANXIOUS	64	17.5	DISLIKE	20	5.5
CONFIDENT	127	34.8	INTERESTED	218	59.7
DISTRESSED	9	2.5	HATE	7	1.9
ENTHUSIASTIC	133	36.4	CHEERFUL	93	25.5
MATTER-OF-FACT	73	20.0	ILLOGICAL	5	1.4
SCARED	12	3.3	BORING	24	6.6
ENJOYS	183	50.1	CHALLENGE	99	27.1
STIMULATED	67	18.4	USEFUL	121	33.2
STRUGGLING	45	12.3	UNNECESSARY	5	1.4
SMART	22	6.0	RELEVANT	55	15.1
SUCCESSFUL	67	18.4	WASTE	3	0.8
FAILURE	4	1.1	IMPORTANT	137	37.5
UNSURE	77	21.0	FORGETTABLE	18	4.9
ABLE	165	45.2			

From table 8.40 the most frequently chosen positive attitude words were INTERESTED (218), ENJOYS (183), ABLE (165), and IMPORTANT (137). The most frequent negative attitude words were UNSURE (77) and ANXIOUS (64).

The t-test on mothers' and fathers' responses failed to yield any significant differences. Thus both parents appeared to have responded in similar ways over the whole sample.

The chi-squared test compared responses of mothers or fathers according to the gender of their child. Only one difference reached significance - IMPORTANT being chosen by fathers of boys. While one significant difference could be expected by chance, it is interesting that the word IMPORTANT reflects the views of researchers that mathematics is seen as more important for boys than for girls.

The chi-squared test was used to compare responses of parents according to pupil gender. Table 8.41 presents the results.

TABLE 8.41 SIGNIFICANT X^2 RESULTS OF WORDS CHOSEN BY PARENTS OF BOYS AND GIRLS TO DESCRIBE HOW THE CHILD FELT TOWARDS MATHEMATICS

Variable	% of girls' parents	% of boys' parents	Significance
Child feels:			
CONFIDENT	31.1	44.3	0.02
ENTHUSIASTIC	31.1	46.6	0.01
STIMULATED	13.7	26.0	0.01
ABLE	36.1	58.8	0.00

From table 8.41 all significant differences related to positive attitude words with more parents of boys expressing their child to be confident, enthusiastic, stimulated, successful, and able. It should be noted however, that parents of girls did not express more negative attitude words, only less positive words. These findings are consistent with those of the secondary pupil attitude study in which boys displayed a more positive attitude towards mathematics in relation to their confidence and perception of ability, but not to a view of the usefulness of the subject or of mathematics as a male domain. The results also confirm the findings of Fennema and Sherman (1978) who reported boys to be more confident in mathematics even from pre-school years. Meece (1982) suggested that there was a decline in self-concept which precedes the decline in girls' mathematical performance. If this is true then less pronounced gender differences in attitudes would be revealed at the junior age than at the secondary age. The study into junior age pupil attitudes however, found that girls expressed difficulty and dislike of mathematics significantly more than boys and a lack in self confidence of mathematical ability even at this primary age. All pupils had perceived teachers to regard boys more highly in mathematics by praising them more than girls.

To summarise, it appears that parents perceptions of their children are consistent with the pupil attitude results that was reported in sections 8.21 to 8.23, that while there is little evidence to suggest that girls have a negative attitude towards mathematics, there is evidence that they have a lower positive attitude than boys. While the junior attitude study and parent attitude study has so far suggested a lower self-concept and less positive attitude towards mathematics than boys, to examine Meece's theory that girls' self-concept declines with age, the parent perceptions of their children must be analysed relative to the age of their children. A decline in motivation and increase in anxiety related to mathematics may be due to the style of teaching and, as reported earlier in the present study, class teaching increased with age of pupil. The ORACLE study (Galton and Willcocks, 1983) reported an increase in anxiety prior to transfer to a new school and then a decrease over the following year. However, the anxiety measured for that study related to general anxiety rather than to mathematics alone. The question now arises as to whether anxiety and motivation increases with age too. Table 8.42 presents the significant chi-squared results comparing responses by age.

TABLE 8.42 SIGNIFICANT CHI-SQUARED RESULTS OF PARENT RESPONSES ACCORDING TO THE AGE OF THE CHILD

Word	% Infants	% 2Jnr	% 4th Jnr	% Secondary	% Significance
Child feels:					
ANXIOUS	7.6	15.7	17.6	31.7	0.003
ENTHUSIASTIC	43.9	41.8	33.3	22.2	0.027
ENJOYS	62.1	61.2	39.2	31.7	0.000
STIMULATED	28.8	20.1	13.7	11.1	0.030
STRUGGLING	1.5	11.2	15.7	20.6	0.010
ABLE	34.8	55.2	37.3	47.6	0.010
CHEERFUL	36.4	34.3	14.7	12.7	0.000
BORING	0	5.2	7.8	14.3	0.010
CHALLENGE	10.6	32.1	29.4	30.2	0.010
USEFUL	7.6	35.8	33.3	54.0	0.000
RELEVANT	3.0	17.2	14.7	23.8	0.010
IMPORTANT	12.1	40.2	40.2	54.0	0.000

From table 8.42, frequency of selection of ANXIOUS monotonically increased with the age of pupil, with nearly one third of all parents of secondary age pupils choosing ANXIOUS. Other words whose frequency of selection increased monotonically were STRUGGLING and BORING. While selection of these negative attitude words increased with age, many positive attitude words decreased viz. ENTHUSIASTIC, ENJOYS, STIMULATED, and CHEERFUL. As the age of the children increased, parents appear to have perceived their children as being more anxious and struggling, and having less motivation in the form of enthusiasm and enjoyment. Useful, relevant and important remained high from junior through to the secondary age.

This result suggests, therefore that Meece's assertion of girls' self-confidence declining with age holds true, according to the parental perceptions of their children, but so too does the self-confidence of boys decrease. The link between loss of self-confidence and decline in mathematical performance is tenuous. It must also remain uncertain whether the increase in anxiety found in the ORACLE study was due to the forthcoming transfer to a new school, or whether anxiety in general increases with age for several interrelated reasons.

8.24.6 SUMMARY

Parents were generally positive in attitude towards mathematics but more mothers than fathers selected negative attitude words related to anxiety and ability. By acting as role models, mothers may convey this lesser positive attitude and greater anxiety to girls, while fathers convey a high positive attitude to boys.

Both mothers and fathers reported that they would feel positive if their child was exceptionally bright at mathematics, but more fathers felt their sons saw mathematics as important.

Parents' perceptions of their child's attitudes were consistent with findings reported earlier that boys are more confident in mathematics than girls from the early primary years.

Parents viewed motivation of their child to decline and anxiety to increase as the child's age increased and it was suggested that this change in motivation and anxiety may be related to the extent of class teaching employed by the teacher. It was shown that girls hold a lower self-concept in mathematics than boys and the increase in anxiety in addition may be sufficient to prevent girls from wishing to study mathematics to a high academic level.

The consistency between parents' perceptions of their child's attitudes and actual child's attitudes suggests that parents may act as role models but parents may influence pupils by the way pupils are helped and encourage in mathematics in the home. To investigate the effect of home influences on pupil aspirations a study of several home factors and pupil aspirations was undertaken by use of a questionnaire and is reported in the following section.

8.25 Investigation of Home Influences

The review of the research literature indicated that girls do not perceive masthematics as a subject for boys only, yet view the mathematical needs of girls and boys for their careers to be quite different. Other studies reported a relationship between pupil achievement and parent occupations and educational status. The differential effect of these parental factors is unclear but parents have been reported to encourage boys to participate in certain hobbies which are conducive to mathematical development e.g. lego play, while mothers pass on a fear of mathematics by acting as a role model. Socio-economic factors also complicate the evidence as manual workers are reported to give less encouragement to their children than middle-class parents.

The present study's findings have suggested a strong link between parents' perceptions of their children's attitudes and pupils' perceptions of their own attitudes with boys expressing more confidence than girls. Evidence was produced to suggest that mothers did have less confidence and more anxiety than fathers and therefore may act as role models for daughters, while fathers, who expressed greater confidence, may convey more positive attitudes to sons. To investigate other home influences a questionnaire was devised to gather information related to the factors mentioned above viz. parent occupations, pupil hobbies and pupil aspirations.

8.25.1 THE INSTRUMENT

The instrument used to gather information about home backgrounds was a questionnaire requiring short answer responses. The information collected related to parent occupation, siblings, career aspiration, hobbies, and identification of the years in which male and female teachers taught the pupil concerned. Figure 8.3 presents an example of a questionnaire.

8.25.2 PROCEDURE AND ADMINISTRATION

The questionnaires were completed by the pupils themselves except for the infant age where questions were asked verbally and the visiting observer filled in the questionnaires according to the pupils' responses.

The questionnaires were administered to each junior and secondary pupil who was a target for the observational study of behaviour reported earlier. The pupils were requested to complete the questionnaire

STUDENT BACKGROUND.

NAME Adnan BOY OR GIRL Boy

DATE OF BIRTH 14-12-83 CLASS 4C

Have you always lived in Great Britain ? Yes

What is your father's occupation ? Marketing Manager

What is your mother's occupation ? House Wife

How many older brothers do you have ? 0

How many younger brothers do you have ? 0

How many older sisters do you have ? 1

How many younger sisters do you have ? 0

Do you have any brothers or sisters the same age as you ? No

What kind of job do you want to do when you leave school ? Footballer

Who helps you with your maths at home ? My Mum.

How many girls are in your class when you do maths ? 17

How many boys are in your class when you do maths ? 15

Underline which of the following you like doing :-

CHESS FOOTBALL TENNIS HOCKEY DRAUGHTS MODEL-MAKING

JIG-SAWS CROSSWORDS

What other things do you like doing ? Squash, Cricket,

What class are you in at school now 1ST Yr Infants, 2nd Yr Infants, 1st Yr Juniors 2nd Yr Juniors, 3rd Yr Juniors, 4th Yr Juniors, 1st Yr High, 2nd Yr High.

In what school years did you have a man teacher ? 1st Yr Infant, 2nd Yr Infant, 1st Yr Junior, 2nd Yr Junior, 3rd Yr Junior, 4th Yr Junior, 1st Yr High, 2nd Yr High

In what school years did you have a woman teacher ? 1st Yr Infant, 2nd Yr Infant, 1st Yr Junior, 2nd Yr Junior, 3rd Yr Junior, 4th Yr Junior, 1st Yr High, 2nd Yr High

Figure 8.3

immediately and then to hand it in to the observer. For the infant age pupils, a special visit to the classes was made to collect the required information. The infants remained in their own classroom with the observer interviewing the child who was seated at his/her own place.

8.25.3 STATISTICS

The questions relating to future career aspirations and parent occupations were coded according to the following categorisation:

1. ACADEMIC/PROFESSIONAL - doctor, teacher, vet, pilot, scientist, computer programmer/analyst
2. ART - designer, dancer, hairdresser, actor, make-up artist, stuntman, architect.
3. MEDICAL (NON-ACADEMIC) - nurse, physiotherapist.
4. SERVICES - RAF, police, religious orders.
5. SPORT - footballer, motor-bike scrambler.
6. ENGINEERING - mechanic, machinist.
7. CLERICAL/SHOP WORKERS - secretary, business, landlord.
8. LABOURER - farmer, cleaner, milkman, driver, painter, bookmaker, forrester, train driver, caterer, builder.
9. UNEMPLOYED - housewife/husband, retired, unemployed.

Codings were also used to describe who helped the pupil at home with their mathematics.

0. NO-ONE
1. MOTHER
2. FATHER
3. MOTHER AND FATHER
4. SISTER
5. BROTHER

The open-ended question on children's hobbies was classified under the following headings:

1. SPORT
2. COOKING/SEWING/WOODWORK
3. READING
4. MUSIC/DANCING
5. LEGO/GAMES
6. ASTRONOMY/SCIENCE

1. General frequences and percentages of codings for each question were obtained.
2. Chi-squared was used to test the difference between boys and girls in types of hobbies followed.
3. Pearson's r correlation was used to compare high, medium and low achievement for types of hobbies.

8.25.4 RESULTS

A total of 62 questionnaires from boys and 64 from girls were completed and analysed.

Table 8.43 presents details of the number of pupils in the study who had brothers and sisters. This information was necessary in order to interpret the question relating to who helps the pupils with their mathematics at home. If a pupil did not have any brothers and sisters, then the availability of help would have been limited.

TABLE 8.43 DETAILS OF SIBLINGS OF PUPILS IN THE STUDY

	%
At least one older brother	33.8
At least one younger brother	28.6
At least one older sister	34.3
At least one younger sister	31.3
A twin	2.3

From table 8.43 above, about one third of all pupils had at least one older brother, and one third a younger brother. Just over one third of the pupils had an older sister and a third had a younger sister. Given that most children belonged to two or three child families, a large number of the pupils in the present study had access to help from siblings. Table 8.44 describes the source of help for the pupils.

TABLE 8.44 DESCRIPTION OF WHO HELPS THE PUPIL WITH MATHEMATICS AT HOME AT THE DIFFERENT AGE GROUPS

Age	Infant	2nd Jnr	4th Jnr	Secondary
HELP BY:				
No-one	60.0	40.0	31.6	28.1
Mother	20.0	13.3	23.7	18.7
Father	13.3	10.0	23.7	18.8
Mother and Father	6.7	26.7	18.4	21.8
Sister	0.0	6.7	0.0	6.3
Brother	0.0	3.3	2.6	6.3
N	15	30	38	32

At the infant age, 60% of the pupils said that no-one helped them with their mathematics at home. This high percentage is likely to be due to infants rarely receiving mathematics to take home, unlike reading books.

Of the infants who did refer to someone giving them help, the majority chose Mother (20%) and the rest either Father (13%) or both (7%). At the 2nd year junior age both the mother and father featured highly as a source of help at home, similarly at the 4th year junior and secondary ages. Help from sisters and brothers featured much lower, being mostly at the 2nd year junior and secondary ages.

Given that a fairly high proportion of pupils reported to have help from no-one with their mathematics at home, it might be expected that higher achievers receive more support from their family than low achievers. Table 8.45 describes who was reported to help with mathematics according to the achievement level of the pupil.

TABLE 8.45 DESCRIPTION OF WHO HELPS THE PUPIL WITH MATHEMATICS AT HOME ACCORDING TO DIFFERENT ACHIEVEMENT LEVEL OF THE PUPIL

Ach.	High	Middle	Low
HELP BY:			
No-one	33.3	35.9	46.2
Mother	22.2	12.8	17.9
Father	20.0	23.1	7.7
Mother and father	15.6	20.5	23.1
Sister	6.7	2.6	2.6
Brother	2.2	5.1	2.6
N	45	39	39

In table 8.45 more low achievers than middle and high achievers, reported that no-one helped with their mathematics. Mothers were reported to help high and low achievers, while fathers rarely helped low achievers. Slightly more sisters were reported to help the high achievers, whereas brothers helped middle achievers. Researchers have suggested that children's attainment levels are related to their mother's occupation rather than their father's. If this is so, then high achievers, with mothers in high status occupations, would act as a model for daughters such that pupils are more likely to seek help from a sister than a brother. Table 8.46 shows the distribution of mothers' and fathers' occupations.

TABLE 8.46 DISTRIBUTION OF MOTHERS AND FATHERS OCCUPATIONS

	% of Fathers	% of Mothers
Occupation:		
Academic	6.4	4.0
Art	2.8	1.6
Medical	0	8.1
Services	0.9	0
Sport	0	0
Engineering	34.9	0.8
Clerical	12.8	24.2
Labourer	34.9	25.8
Unemployed	5.5	33.9
Other	1.8	1.6

Fathers were mainly in engineering (34.9%) or some form of labour work (34.9). Only 6.4% were classified as academic/professional and 5.5% unemployed. No fathers worked in the medical profession as a nurse or physiotherapist which has been a traditionally female occupation. Mothers were mainly unemployed e.g. housewives, others being clerical workers or in some form of labour work. The figures demonstrate traditional roles for male and females, with women in the caring profession of nursing, and housewifery, and men in engineering and labour intensive work. As one third of the mothers were unemployed it is possible that these mothers were from families from higher socio-economic status. As academic achievement has been found to correlate with socio-economic status, then it would be expected that higher achievers come from either the housewives or, owing to the effect of role modelling, from the higher status occupations. Table 8.47 presents details of parent occupations according to achievement level of the pupils.

TABLE 8.47 FATHERS' AND MOTHERS' OCCUPATIONS OF DIFFERENT ACHIEVEMENT LEVEL PUPILS

	FATHERS			MOTHERS		
	High	Middle	Low	High	Middle	Low
Academic	12.8	5.9	0.0	4.5	2.5	0.0
Art	0.0	0.0	8.8	0.0	2.5	2.8
Medical	-	-	-	13.6	5.0	5.6
Services	0.0	2.9	0.0	-	-	-
Sport	-	-	-	-	-	-
Engineer	28.2	44.1	35.4	2.3	0.0	0.0
Clerical	20.5	8.8	8.8	20.5	27.5	27.8
Labour	30.8	32.4	44.0	18.2	25.0	38.8
Unemployed	7.7	5.9	3.0	40.9	37.5	25.0

More high achiever pupils had fathers in academic and clerical work than middle or low achievers, whereas more low achievers had fathers working in engineering or labour work of some kind. High achiever mothers were mainly unemployed and this level was much higher than for low achievers. While high achiever mothers were also clerical workers and labour workers, the levels were much lower than for the middle and low achiever pupils. None of the low achieving pupils had parents in academic occupations. These results seem to indicate a strong link between occupation status of parents and achievement of pupils. However, the interrelation between occupation and socio-economic factors makes it impossible to conclude whether pupil achievement is due to role modelling or to provision for study at home such as books, room to study, etc. It may be that by acting in role models, pupils will aspire to enter careers of a similar level to that of their parents. Table 8.48 presents the details of career aspirations according to their father's occupation.

TABLE 8.48 PUPIL CAREER ASPIRATIONS IN RELATION TO FATHER'S OCCUPATION

	CAREER ASPIRATIONS								
	Acad	Art	Medic	Serv	Sport	Engin	Cleric	Labour	Unemp
FATHER'S OCC									
Academic	2	2	1	0	1	0	0	0	0
Art	1	0	0	1	0	0	0	0	0
Medical	-	-	-	-	-	-	-	-	-
Services	0	0	0	0	1	0	0	0	0
Sport	-	-	-	-	-	-	-	-	-
Engineer	2	7	3	4	3	3	2	1	0
Clerical	0	2	0	3	1	1	0	1	0
Labour	7	4	1	8	2	0	3	6	0
Unemployed	1	0	0	1	0	0	2	0	0

Children with academic fathers aspired to academic, art, medical or sporting careers, with none choosing careers in labour work or engineering. Pupils of engineering fathers chose mostly art careers but the distribution across the other careers was widespread, including two pupils aspiring to academic/professional careers. Pupils with fathers in labour work occupations were also widely distributed, with high numbers of pupils choosing academic careers, the services, and labour work. It appears, then, that while most pupils are willing to consider a wide range of careers, academic parent's children are more limited in their choice and do not consider a future in labour or engineering type of work. It may be, therefore, that pressure from families of lower soci-economic status is less rigid and pupils have a choice over their career choice, whereas academic families pressure their children such that they are expected to achieve and they therefore live up to the expectations.

TABLE 8.49 PUPIL CAREER ASPIRATIONS IN RELATION TO MOTHER'S OCCUPATION

	Acad	Art	Medic	Serv	Sport	Engin	Cleric	Labour	Unemp
Academic	1	0	1	1	0	2	0	0	0
Art	1	0	0	0	0	0	0	0	0
Medical	3	1	0	2	0	2	1	0	0
Services	-	-	-	-	-	-	-	-	-
Sport	-	-	-	-	-	-	-	-	-
Engineer	0	1	0	0	0	0	0	0	0
Clerical	3	6	2	3	3	0	1	3	0
Labour	4	3	3	4	2	1	1	4	0
Unemployed	5	5	1	7	4	0	5	2	0

Career aspirations related to the mother's occupation was much more widely distributed than when related to the father's occupation. It appears, therefore, that career aspirations are linked more to father's occupations than to mothers.

The desire of girls to be nurses and teachers, and for boys to be policemen and firemen has often been reported to be the traditional career aspirations of young children. If the fathers' occupations do influence pupil aspirations, the question remains as to at what age it has most effect given that young children usually aspire to those traditional roles outlined above. Table 8.50 presents details of the career aspirations of pupils at different ages.

TABLE 8.50 CAREER ASPIRATIONS OF GIRLS OF DIFFERENT AGE GROUPS

	Infant	2Jnr	4Jnr	Secondary	Total
Academic	5	3	3	3	14
Art	1	1	5	3	10
Medical	2	3	0	2	7
Services	0	1	1	1	3
Sport	0	0	0	0	0
Engineer	0	0	0	0	0
Clerical	1	2	4	1	8
Labourer	0	0	1	0	1

Note that only 43 out of 69 girls expressed a career choice.

Infant and second year junior children aspired to academic work (teachers) or to medical work (nurse). This career choice is consistent with the expectations of the traditional gender role. Fourth year junior children had a slightly wider choice of careers to include academic, art, and clerical work. By the secondary age choice had become academic, art, and medical again, i.e. the traditional female roles again. It appears, therefore, that if fathers' influence does have effect on pupil career choice it is likely to be sometime after the second year junior age, which again coincides with other changes reported earlier in the present study.

TABLE 8.51 CAREER ASPIRATIONS OF BOYS OF DIFFERENT AGE GROUPS

	Infant	2Jnr	4Jnr	Secondary	Total
Academic	1	1	1	0	3
Art	0	0	3	3	6
Medical	0	0	0	0	0
Services	3	2	5	3	13
Sport	2	5	3	0	13
Engineer	1	1	0	3	5
Clerical	0	0	0	0	0
Labourer	2	3	1	1	7

Note that only 47 out of 65 boys expressed a career choice.

Infant and second year junior boys chose the services, sport, and labour work - again a traditional gender role selection. The fourth year junior age and secondary age showed a variation in choice of career including art, services, sport and engineering. The evidence does, therefore, again indicate the importance of the post-second year junior age with regard to change in the pupils.

One of the possible changes at the middle primary age is the hobbies followed by girls and boys. Researchers have suggested that boys engage in hobbies which are conducive to mathematical development such as chess, lego and model making. Table 8.52 presents the chi-squared significances between choice of specific hobbies of girls and boys.

TABLE 8.52 CHOICE OF HOBBIES OF BOYS AND GIRLS WITH CHI-SQUARE SIGNIFICANCES

	Boy	Girl	Significance
Chess	18	14	NS
Football	47	14	0.000
Tennis	23	36	0.07 NS
Hockey	7	19	0.02
Draughts	17	12	NS
Model Making	30	23	NS
Jigsaws	18	28	0.08 NS
Crosswords	13	23	0.06 NS
N	62	64	

The only differences to reach significance were sport activities - football and hockey. Jigsaws and crosswords both approached significance, with girls engaging in these activities more than boys.

TABLE 8.53 CHOICE OF EXTRA HOBBIES BY GIRLS AND BOYS

	Boys	Girls
Sport	35	3
Cooking/sewing /woodwork	0	4
Reading	3	6
Music/drama	3	7
Lego/games	10	7
Astron.science	1	0

When pupils were given the opportunity to mention other interests than those specified, many boys mentioned some form of sport, and some mentioned lego and other games. Less girls responded to this section of the questionnaire, but those who did displayed variety in choice of interests. The choice of lego, and other activities thought to promote development of mathematical concepts, then it would be expected that high achievers exhibit a preference for these hobbies than low achievers would.

TABLE 8.54 CHOICE OF HOBBIES BY DIFFERENT ACHIEVEMENT LEVELS WITH CORRELATION SIGNIFICANCES

	High	Middle	Low	r	Sig.
Chess	13	10	9	-0.05	NS
Football	22	20	19	-0.00	NS
Tennis	24	18	17	-0.06	NS
Hockey	10	8	8	-0.02	NS
Draughts	15	7	7	-0.15	0.05
Models	19	17	17	0.01	NS
Jigsaws	18	10	18	0.04	NS
Crosswords	15	13	8	-0.11	NS
N	46	40	40		

Only one hobby displayed a difference between achievement levels, with draughts being played by more high achievers. It is interesting that chess was not found to be played significantly more by high than low achievers as had been thought.

TABLE 8.55 CHOICE OF EXTRA HOBBIES BY ACHIEVEMENT LEVEL

	High	Middle	Low
Sport	25	24	19
Cook/sew /wood	2	1	1
Reading	4	3	2
Music	3	1	4
Lego	7	4	6
Astron/sci	1	0	0

From table 8.55 above, there was little difference in choice of extra hobbies reported by high, middle and low achievers. There is, therefore, no evidence that choice of certain hobbies influences pupil achievement in mathematics.

The final part of the questionnaire asked for information about the gender of teachers the pupils had experienced throughout their school lives. Some pupils could not remember all of their teachers, but the results of the replies received are presented in the table below.

TABLE 8.56 PERCENTAGES OF PUPILS HAVING HAD A MALE TEACHER AND FEMALE TEACHER AT DIFFERENT AGES THROUGHOUT THEIR SCHOOL LIFE

School Year	Male Teacher	Female Teacher	Don't Know
1st Infant	5.2	66.4	28.4
2nd Infant	3.7	61.9	34.4
1st Junior	14.9	52.2	32.9
2nd Junior	22.4	45.5	32.1
3rd Junior	23.9	23.1	53.0
4th Junior	25.4	20.1	54.5

From the above table, there was a steady decline in the number of pupils who had a female teacher and hence an increase in those who had a male teacher as they progressed throught the junior age. Up to the second year junior age most pupils had experienced female teachers for most of the time, but from the 3rd year junior onwards the numbers of male and female teachers were about equal. This change in experience of teacher gender from the 3rd year juniors coincides with the change in errors found in the study on pupil performance on the Bristol Achievement test. In the study of errors, a change in mathematical topic areas in which girls and boys were prone to conceptual errors, and which may have caused a 'fear of failure', changed sometime between the second and fourth year junior ages. The topic areas concerned at these ages were those consistent with findings of earlier research studies in which it was found that girls generally achieved lower levels than boys. The evidence appears to point out that the increase in use of male teachers goes hand in hand with the increase in whole class teaching, and together seems to lead to less positive attitudes and less self-confidence in girls. It is also interesting that these changes at about the third year junior age also coincide with the change in pupil career aspirations.

8.26 Summary

The present study has argued that if Dweck's 'fear of failure' is true, then it occurs in specific mathematical topics only and manifests itself sometime between the second and fourth year junior age. As few differences in pupil behaviour have been reported in the present study, it seems possible that manifestation of a 'fear of failure' is linked to attitude change.

While attitudes themselves are not observable, their effects are and there is a need for use of psychometric tests to assess attitudes. While older children can be tested with instruments based on Likert-type questionnaires, young children need visual objective measures which reduce the need for large amounts of language such that motivation is held.

Secondary pupils all thought mathematics was useful for their future lives but boys expressed more confidence and less anxiety than girls. There appears to be some evidence of home background influences on pupil attitudes, with low socio-economic status being related to less positive attitudes.

Junior pupil attitudes were assessed using an innovative method combining cartoon drawing and incomplete sentences. Scorn and nastiness between the sexes, and a strong feeling of competitiveness between opposite sex pupils and comradeship between same-sex pupils was apparent from the earliest age studied. Pupils also viewed boys as receiving more praise for good work from the teacher even though the behaviour study found this not to be so. The view of gender as a factor of life was, therefore, conveyed to the pupils sometime prior to the second year junior age and may suggest the influence of home background experiences. These strong gender views may affect the choice of subject at higher achievement levels.

A change in pupils' emphasis of response occurred sometime between the second and fourth year junior ages. Pupils at the second junior age responded by referring to non-task matters but fourth year juniors focussed on the task much more. This change coincides with the manifestation of a 'fear of failure' evidenced by the occurrence of errors and omissions studied in the mathematical test investigation.

Pupils from schools set in low socio-economic areas put less emphasis on task matters than other pupils but this was true for all achievement levels.

Nearly all pupils viewed the teacher as a keeper of discipline regardless of actual teacher behaviour in the classroom. This result provides some evidence, therefore, that pupils' perceptions are reflective of previous experience or of stereotypes which have been conveyed to them in some way. A perception of teacher behaviour stereotypes is evident at the second year junior age and it is likely that gender stereotype perceptions are present too by similar means.

Teacher attitudes were found to be generally positive towards mathematics (both the subject and the teaching) but some anxiety was nevertheless expressed. Specialist mathematicians did express more liking and confidence than non-specialists but teacher gender differences showed that male teachers were slightly more positive and confident than female teachers. Female teachers did not, however, express negative feelings towards mathematics and therefore the possibility that female teachers acting as role models for girls to underachieve in mathematics seems unlikely. It may be, however, that male teachers model a more positive attitude to boys thus affecting boys' achievement levels. The data on teacher gender shows that pupils have female teachers mainly up to the second year junior age and that pupils have a possibility of male and female teachers from the third year juniors upwards. Male teachers may, therefore, be sufficient in number from the third year juniors to influence boys in their approach to mathematics.

The parent attitude study revealed mothers to be less positive towards mathematics than fathers, but as *with male and female teachers, they were* not actually negative. Mothers did, however, express more anxiety and may, by acting as role models, convey this to their daughters. This could subsequently affect the choice of study in later school years, with girls opting for less-anxiety provoking subjects. Parents' perceptions of child attitudes confirmed the higher self-confidence of their sons.

Motivation of children appeared to decline with age, and anxiety increase for all pupils. This change may be related to the level of class teaching which, as discussed earlier in the present study, increases with age. There does, therefore, appear to be an increase in the number of male teachers accompanied by an increase in the amount of class teaching in mathematics, an increase in pupil anxiety, and a decrease in motivation. It seems possible that these factors are interrelated and work to the detriment of girls.

Parents tended to work in traditional 'gender role' occupations and pupil career aspirations were related to fathers' occupations but the link between parent occupation and their own achievment level cannot be separated from socio-economic status and therefore it is not possible to say whether links between pupil aspirations and parent occupations is due to role modelling or to material effects such as provision of books. Choice of hobbies did not appear to relate to achievement level.

Infant pupils aspired to the traditional roles of teacher and nurse for girls, and fireman and policeman for boys, but a change occurred between the second and fourth year junior age. The change in errors and omissions in mathematical tests, change in career aspirations, and in experience of gender of teacher, teaching style, anxiety and motivation, all go to suggest that the period between second and fourth year junior age is crucial to the development of mathematical concepts and intervention at or prior to this age would seem to be important to prevent the underachievement of girls.

CHAPTER 9

CONCLUSION AND DISCUSSION

9.1 Summary of the Implications of the Findings of the Study

The present study has recognised the need both for highly qualified mathematics specialists, and also for higher mathematical attainment of all pupils in order to service the demands of this technological world. There is a shortage of mathematics teachers which inevitably results in poorer teaching of the subject in schools, and subsequently leads to a shortage of specialist mathematicians. While this shortage remains, the limited supply of people with mathematical expertise will almost entirely be taken up by industry who are able to offer greater financial rewards than can the educational institutions. The shortage of mathematics teachers seems certain to remain. The problem is, therefore, one of how to increase the supply of mathematicians such that the needs of both industry and education can be met.

Statistics on examination results demonstrate that there is a generally small number of pupils who study mathematics to a high academic level, and from the discussion above, it is desirable that this number should increase. More significantly, there are many fewer girls than boys studying mathematics to this high level. It follows then, that if the emergence of a greater number of mathematicians is limited by the shortage of well-qualified mathematics teachers, then there is a need to increase the number of girls who study mathematics as presumably, the establishment of co-educational comprehensive schools has led to the majority of girls being taught by exactly the same teachers as boys who <u>do</u> choose to study mathematics at that high level.

Girls are, therefore, a potential source of the mathematical expertise needed by society. There is also a need to increase the number of boys who study mathematics within the limitations of the supply of well-qualified mathematics teachers. By studying factors which affect girls such that they fail to study mathematics, the present study has attempted to identify reasons as to why other pupils remain low attainers.

In addition to the failure of girls to study mathematics at a high level, there have been several reports of the phenomenon of girls achieving as well or better than boys in mathematics in the primary school, but of boys becoming superior to girls sometime between 10 and 13 years of age and remaining so thereafter. In contrast, girls have shown superiority over boys throughout the school years in Language. Many researchers have based their investigations on the belief that study of factors related to the 10 to 13 year age group would reveal the causative factors for the 'change-over' phenomenon. The present study, however, has argued that factors from an early age are so important that their effects accumulate until they manifest at 10-13 years of age and result in the underachievement of girls in mathematics.

Research on the change in superiority of girls and boys in mathematical performance has led to the identification of a large number of variables which are possible contributors to the cause of gender differences. The main theories of causative factors have related to

1. Biological factors
2. Cognitive skills
3. Social factors

Theories of biological factors have included the suggestion of existence of hemispheric differences between girls and boys such that the hemisphere associated with language is well developed in girls, whereas the other hemisphere associated with mathematical development is well developed in boys. Other biological suggestions include the involvement of hormones on neurone activity such that at adolescence, 10-13 years of age, the change in hormones leads to increased activity in different parts of the brain with boys becoming superior in logical thought needed for mathematics and girls superior in language skills. While it has to be accepted that genetic potential may be influential on intellectual development, the effects are likely to be diminutive compared to the pressures of social and cultural factors such as the environment, parental encouragement, and teacher influence. Biological differences related to mathematical ability, if they exist, can be accommodated but not changed by the teacher and it is argued that environmental factors can also influence biological changes. It would seem reasonable, therefore, to suggest that certain treatment of pupils can result in different reactions of girls and boys to the detriment of girls' performance in mathematics. It is, therefore, relevant to the class teacher to try to understand why girls underachieve relative to boys and to find ways to counteract the problem.

One social factor which has been thought to influence girls' mathematical achievement is pupil attitude, but the question remained as to when attitudes are formed and whether they are fixed such that intervention programmes would have no effect after a specific age. Both Cockcroft (1982) and Newbold (1977) have suggested that attitudes are fixed by the age of 11 and if this were true there would be a need to assess pupil attitudes during the primary years, and to identify those pupils requiring an intervention programme. Once intervention is deemed to be necessary, the type of intervention that would be effective has to be determined.

Parental influence was a second social factor believed to affect both pupil performance and choice of study in later years (Mellin-Olsen,1976). If parents do affect pupil attitudes and subject choice then the effect of parental involvement becomes a classroom factor as the teacher may need to modify pupil attitudes, or in some way liase with parents to encourage children in opting to study mathematics, or, at the extreme, to insist on the study of mathematics such that there is no option.

The issue most pertinent to the classroom teacher, however, is the effect of the teacher's own influence on pupil achievement. The organisation, teaching style employed, the use of praise and criticism, the teacher's role as a 'model' for their pupils, and their expectations of pupil success or failure have all been cited as possible variables contributing to the underachievement of girls in mathematics.

The present study has argued that if these factors are operating in the classroom in the present climate, then there must be historical reasons for the present situation. The evidence cited in chapter 2, the review of the historical considerations of mathematics education for girls and boys, illustrated that mathematics first developed from astronomy which had religious foundations, and as religion was very much a male domain, learning of mathematics was restricted to a <u>few</u> men only as it resulted in a status of power. While some men did see mathematics as something for all people to share (e.g. Pythagoras) there was tremendous social pressure from high status religious members to limit mathematical knowledge to those in religious orders. Mathematics was, therefore, taught to only a privaleged few and equality of opportunity of study for men and women was impossible.

The review has revealed, however, that some early women did succeed in studying mathematics e.g. Hypatia, but the success appeared to be dependent on the support and influence of fathers and male friends. The importance of support by fathers and friends appeared to be in their influence on the formation of motivation and attitudes which are necessary for girls to study mathematics in a climate of utilitarian education. Social pressures were effective in preventing education for women in any curriculum area, but for mathematics the pressure remained for a greater length of time, possibly due to an emphasis on education for utilitarian purposes.

A long history of a shortage of mathematics teachers resulted from the lack of desire for mathematics to be taught to either men or women, and with many schools being single-sex institutions, owing to their foundations, it was inevitable that the mathematics teachers, who were mainly male, were found in all-boys' schools. Thus the rise of mathematics within the curriculum led to the inevitable conclusion of inferior provision of mathematics teaching for girls.

A utilitarian approach to education prevailed for a long time and girls were reared to be housewives, with parents and society emphasising education for boys who were to be the main 'breadwinners' of the family. Change in policy has proved to be very slow and difficult. Disturbingly, where changes in education have been advocated e.g. use of practical mathematics by Hadow in 1926, teachers appear to have been reluctant to implement changes and it is, therefore, important to consider not only what needs to be changed to increase girls' mathematics achievement level but also the ways in which change can be implemented.

The historical aspect does illustrate clearly how the achievement in mathematics of girls came to be behind that of the boys. It also suggests that mathematics was a relatively late addition to the curriculum and therefore may contribute to the reason for few pupils choosing to study it at a high academic level compared to other curriculum areas.

Having determined that history has had a role to play in the situation today regarding mathematics education of girls, the factors which are involved in keeping the situation working to the detriment of girls need to be identified. The evidence of underachievement in recent years, reported in chapter 3, was provided by statistics of public examinations which showed that while few girls achieved passes at a high academic level, it was not due to girls failing but to them not being entered for such exams. Two possible reasons may account for this - 1) girls do not wish to enter the higher level exams, regardless of their ability to do so, and therefore fail to take up the option of study, or 2) teachers expect girls, rightly or wrongly, to have difficulty with the subject and therefore discourage them from opting to study mathematics to this high level.

While some research studies have reported superior performance of boys in mathematics from adolescence, there were others who reported superior performance of girls. In the early stages of interest in gender differences, the tendency was for significant results only to be published. It was only after a substantial interest in the area had been demonstrated that insignificant results became published too. Early findings did, therefore, present a biased view that gender differences did occur. It was only after the more recent publications that the underachievement of girls was found not to be as serious as some critics of the educational system had originally argued. No conclusive evidence has been produced to suggest that gender differences in mathematical achievement occur at the primary age. At the secondary age, the few reports of superiority of boys appears to be limited to certain topic areas within mathematics e.g geometry, while superiority of girls was limited to computation, and even then findings of superiority were limited to certain schools and not others.

The present study supports the above findings with gender differences in mathematics test results being limited to specific classes and could not be said to be the general case. There is, therefore, no support for biological theories as a sole cause of underachievement of girls. If gender differences were due to biological factors alone, then one would expect differences in performance to be found in the majority of classes rather than just a few.

While the evidence for gender differences in mathematical achievement is inconclusive, there has to be some reason to account for the occasions when differences do occur. Various hypotheses have been put forward to explain the underachievement of girls. Sherman (1967) suggested that girls' lack of practice in developing spatial skills, such as those developed by use of lego and model making, is the cause of girls' underachievement. Various researchers have produced evidence that this lack of practice cannot be the sole cause of underachievement although it may be a partial cause (e.g. Krutetskii,1976 who found that successful mathematicians used strategies some of which were spatial and some which were not). The present study confirms this assertion by reporting that gender differences were not found in the type of hobbies followed such as lego building, model making, jigsaws, etc. either between the sexes or between different achievement levels.

When performance of girls and boys was compared within different mathematical topics, the present study found evidence of superiority of boys in the topic of Measurement only, and at the 2nd year junior and secondary ages only. Measurement proved to be the most difficult section for all pupils and the superiority of boys may have been due to girls omitting responses rather than to their getting them wrong. This result, relating to difficulty of item, is opposite to the findings of the infant test study which, while failing to find any gender differences in total test scores, found superiority of boys in the easiest section of Time and Money, and superiority of girls in the most difficult section of Fractions. There appeared to be some influence of a language factor in determining the level of ease or difficulty of the test items, but another possible explanation for this differential performance could be the effect of parental and other home influences where boys tend to be given a watch and be sent shopping whereas girls become involved in cooking with ½ tsp. etc., but this must remain conjecture.

Pupil attitudes are also thought to influence classroom behaviour. It was theorised that if girls are less confident and more introverted than boys, then they will fail to approach the teacher for help. Instead girls were thought to get help from peers which could subsequently result in girls forming their own strategies for solving mathematical problems and lead to conceptual errors which would hinder further progress. Cox (1975) reported that errors go unnoticed by the teacher for a long time and there is therefore a need for teachers to be able to assess conceptual errors from written work. The present study used a classification system of looking at errors from which it was determined that girls do not make more conceptual errors than boys until sometime between the 2nd and 4th year junior ages, and then at the secondary age tend to omit responses rather than, perhaps, risk demonstrating conceptual errors. It is, therefore, at this secondary age that Dweck's theory of a 'fear of failure' is consistent with the findings of the present study when based on total test scores. When mathematics is separated into topics, however, the evidence for Dweck's theory is inconsistent and Dweck's hypothesis can only be supported by the present study if it is accepted that the effect of conceptual errors builds up and manifests later at the secondary level, and even then is limited to certain mathematics areas only.

This argument raises the question of whether secondary age girls omitted responses because of a fear of demonstrating conceptual errors, or whether it was due to them not understanding what the question required of them. If language was the cause, then this would be inconsistent with reports of girls' superiority in language skills. If they 'fear failure', then one would expect to find evidence of low self-confidence in girls.

The evidence of the present study does, therefore, suggest that infant errors may be caused by limitations in their language skills while older pupils' errors are due to either conceptual errors, or to omission of responses which may be due to a lack of confidence in the pupils. Verdelin (1958), Conner and serbin (1980) and Wattanawaha (1977) have all suggested the importance of context and topic of test item content in determining success. The study of errors in the present study supports this finding, going further to suggest that language development could explain why girls have been found by some researchers to be superior to boys in mathematics at the primary age. It is argued that as boys are later in the development of their language skills, gender differences in mathematics tests could be due to difficulty in understanding what is required of them and the test is assessing language development more than mathematical concept aquisition. Donaldson (1978) reported the sensitivity of experimental tasks to variation and the present study's investigation of infant performance on a test of basic experience (Tobe 2) highlighted how the wording used can influence pupil understanding of what is required of them, while their previous experience of language can also lead to misunderstanding. Watson (1980) also reported comprehension and reading ability as a cause of errors in mathematics, while Hart (1980) and Kent (1981) suggested the cause of complexity of an item and limitation of memory.

The present study suggests that teachers encourage language skills until, at 10-13 years of age, most pupils are competent and a levelling out of performance in mathematics occurs. From 10-13 years other factors come into action such that boys appear to be ahead of girls in mathematical performance in some research studies. The presence/absence of pupil gender differences at the primary age would, therefore, depend greatly on whether a school's level of language development was generally good or generally poor.

Some possible effects of a lack in self-confidence of girls has been discussed above in relation to the occurrence of conceptual errors at the fourth year age and the omission of responses at the secondary age. Meece (1982), supported by Marsh (1985), found that a decline in self-concept precedes the decline in girls' mathematical performance and therefore, they suggested, confidence is a strong possible causal factor of the decline. Fennema and Sherman (1977) reported boys to be more confident than girls in mathematics even from the pre-school age. If this is true at such an early age, then the home would seem to be an important influence on the child's academic performance, perhaps partly through the effect of parental encouragement and their role as a model to their children. Luchins and Luchins(1980) reported that more parental encouragement is given to boys than to girls, and although Blatchford (1985) found girls to have higher literacy and numeracy skills, the level was linked to the educational level of mothers and other home background influences. Data from the questionnaire on pupil backgrounds in the present study found that pupil career aspirations were linked to the fathers occupations and not the mothers, and so by acting as a model fathers may influence boys more than girls when the time comes to choose subjects to study at a high level. Added to this influence by parents is the report by some researchers that mathematics is seen as a male domain and therefore girls don't see it as a suitable subject for them to study and may choose areas of the curriculum which have been stereotyped as suitable for girls. The study of parent attitudes revealed mothers to be less positive than fathers towards mathematics, but they were not actually negative. Mothers did, however, express more anxiety and may convey this feeling to their daughters by acting as role models and subsequently lead to girls opting for low-anxiety provoking subjects. Parents tended to work in traditional 'gender role' occupations and also convey a message of gender role to their children.

The investigation of attitudes in the present study revealed girls to have less confidence and poorer attitudes than boys, but girls did not display strongly negative attitudes. Parent perceptions of their children confirmed the pupil attitude results but also suggested that all children's motivation declined with age while anxiety increased. The present study found evidence to suggest that this decrease in motivation and increase in anxiety is accompanied by an increase in the number of male teachers together with an increase in the amount of whole class teaching.

Teaching style is thought to suit some pupils and not others. Rogers (1969) suggested that some formal teaching styles involve an element of competition which results in a feeling of failure by some. For these pupils, therefore, he advocated discovery learning with support. As Dweck (1976) suggested that girls are eager to please and are susceptible to 'fear of failure' then it follows that one would expect girls to be better suited to discovery learning and to be unsuited to more formal methods.

The present study reported teaching style in mathematics to become more formal in terms of whole class teaching from the third year juniors onwards. This increase in formal style coincided with the age at which evidence of a 'fear of failure' appeared in specific mathematics topics, and also with the increase in the number of male teachers. It seems, therefore, that the style of teaching employed appears to be detrimental to the mathematical achievement of girls, perhaps owing to an increase in anxiety. This anxiety may build up over the primary and early secondary years and lead to girls failing to choose to study mathematics as soon as the option not to arises, in order to avoid feelings of anxiety. Boys, however, appear to be unaffected by the more structured class teaching style and therefore anxiety levels, which were found to be lower than for girls, fail to prevent them from studying mathematics.

Re-analysis of the Oracle data found that most pupils in mathematics tended to he Hard Grinders characterised by high contact through class teaching while English pupils were Easy Riders who had high distraction and less formal class teaching. Pupil style appears to be linked to the curriculum area being taught and to the teaching style employed and, therefore, offers an explanation for the underachievement of girls in mathematics but not in other curriculum areas too.

In addition to the influence of curriculum area and teaching style on pupil 'type', the achievement level of the pupil appeared to affect behaviour too, such that, for example, low achiever infants were Fusspots demanding teacher time and attention. The present study failed to find any evidence to suggest that boys actually receive more attention and hence gain more self-confidence than girls. However, it is possible that boys receive more attention than girls in language sessions in which case the effect may carry across to other curriculum areas but in particular mathematics which is suffering from the influence of several other factors at the same time. The investigation of pupil-teacher interactions showed that although girls and boys received similar amounts of attention from the teacher, boys tended to interact with the teacher more about task related matters than girls did. The confidence boys gain in seeking help from the teacher may derive from this more frequent interaction about task.

At the secondary age, pupils of high and middle achievement level listened attentively to the teacher, as Solitary Workers, during high levels of class teaching, while low achievers become Intermittent Workers, losing concentration and engaging in talk with their immediate neighbours. This finding suggests that teachers employ inappropriate teaching styles not only for girls, who suffer from feelings of anxiety, but also for low achieving pupils of either sex.

Given that teaching style appears to have a detrimental effect on some pupils, teacher expectations may also affect the achievement rates of girls and boys. By perceiving girls to have a lower mathematical ability than boys, teachers will react and behave accordingly and subsequently pupils, because of the credibility of this source of judgement, will behave and perform in the level expected of them (Ernest,1974, Bropy and Good,1970). If teachers view education as having a utilitarian emphasis, then expectations of girls' and boys' future career needs would also lead to differential treatment in the classroom.

Behaviour in which teachers are thought to differentiate between the sexes includes use of praise and criticism such that boys receive both more than girls. High amounts of praise would lead to a feeling of high esteem. If boys are low achievers initially, then teachers, according to modern psychological thought, would praise them highly and a false sense of high esteem would prevail.

High use of criticism of behaviour to boys may lead to boys blaming failure on a lack of effort and success on ability. Also, a high contact for language development would lead to self-confidence and demanding style of gaining extra attention from the teacher. But if this was so, one would expect the resulting attitudes to prevail across the whole curriculum area but it does not. Sears (1974) went further to suggest that boys receive criticism for poor behaviour but girls for lack of skills, whereas praise is given to boys for high level cognitive skills and girls for lower levels such as computations thus reinforcing teacher expectations of ability. The present study found some evidence of differential treatment of boys and girls in the classroom with boys receiving more negative feedback than girls. It may be, therefore, that boys become so accustomed to criticism that failure is attributed to lack of effort or luck. However, the level of such feedback was so small that for it to affect achievement, there would have to be a build-up of the effects such that they manifest at a later stage.

Teachers may also affect pupil performance by acting as a role model (Good and Brophy,1971). As most primary teachers are women, who themselves may have low confidence and dislike of mathematics, they may act as a model for girls thus conveying this poor attitude towards mathematics. If female teachers have a lack of confidence they may concentrate on computation and thus model the importance of this aspect of mathematics to girls leading to girls' superiority in computation. Ward (1979) suggested that confidence was linked to the level of qualifications and therefore one would expect mathematics specialists to convey greater levels of confidence than non-specialists. In the present study, teacher attitudes were found to be generally positive towards mathematics and the teaching of it, but some anxiety was expressed too. Mathematics specialists, however, did express more liking and confidence than non-specialists and male teachers rather more confidence than female teachers. So while male teachers may act as a model and convey more positive attitudes to boys, female teachers were not negative towards mathematics, only less positive and, therefore, are unlikely to convey a negative attitude to girls, to whom they are acting as a model. The study of pupils' attitudes involving the use of cartoon drawings and unfinished sentences found all pupils to view their teacher as a discipline keeper regardless of the fact that the behaviour study failed to find evidence of high levels of interaction by the teacher for discipline reasons. This result provides some evidence, therefore, that pupils' perceptions are reflective of previous experience or of stereotypes which have been conveyed to them in some way, and that small factors may be so important that they manifest at a later date. Similarly, stereotypes of male and female roles may be conveyed to pupils through seemingly insignificant experiences. Scorn and nastiness between the sexes, and a strong feeling of competitiveness between opposite sex pupils and comradeship between same-sex pupils was apparent in the present study in pupils from the earliest age studied. The view of gender as a factor of life was, therefore, conveyed to pupils sometime prior to the second year junior age and may suggest the influence of home background. These strong stereotypical views may affect the choice of subject at higher achievement levels. Secondary pupils all expressed mathematics to be useful to their future lives but boys expressed more confidence and less anxiety than girls. While some of this higher confidence may have been gained from father attitudes, classroom factors are thought to contribute to the level of confidence too.

The present study found no evidence to suggest that boys become accustomed to talking to the teacher and hence become more confident in this way. However, from the fourth year juniors upwards, boys did respond to questions more frequently than girls and it may be here that confidence begins to take effect, with whole class teaching having increased, more whole class questionning taking place, and boys being keener to respond and hence appearing to get more task-related feedback than girls. If boys are keener to respond, then teachers may interpret the behaviour as a greater ability of boys in mathematics than girls who do not offer to respond.

There was evidence at the secondary age of girls being more advanced than boys conceptually in mathematics. While girls' interaction with teachers did tend to be about computation more than boys at the primary age, it was apparent that girls were even further ahead by engaging in the application of computation while boys were still developing the analytical skills needed prior to the application stage. Previous research results comparing interaction on computation and analytical skills would, therefore, not reflect the true stage of development of girls and boys.

The most significant finding from the present study has been the apparent importance of the age between the 2nd and 4th year juniors in which a great deal of change takes place. A change in errors and omissions in mathematical tests, a change in career aspirations, and in experience of teacher gender, teaching style, anxiety and motivation, all go to suggest that this junior age is crucial to the development of mathematical concepts and attitudes which are necessary for the study of mathematics at a high level in later years. Intervention during or prior to this period would seem to be important in the prevention of underachievement of girls in mathematics. Many of the factors which appear to affect the achievement of girls also pertain to low achievers generally, and it is important to develop ways in which these pupils can be helped. The following section considers the implications of the findings of the present study and suggests some ways forward to help in improving the number of pupils who study mathematics to a high level and thus to alleviate the shortage of specialist mathematicians and the provision of pupils who are competent mathematicians.

9.2 What Can be Done

The present study has identified several areas where intervention is deemed to be necessary in order to improve the number of girls choosing to study mathematics at a high academic level. The close relationship between girls and low achiever boys in terms of reaction to certain teaching styles suggests that intervention programmes must be relevant to both groups of pupils. While it is important to improve the number of girls who study mathematics, the methods used in doing so must not impede the progress of boys who choose to study the subject.

Recent interest in equality of the sexes in educational opportunities, particularly with reference to poor attitudes and the effects of gender stereotyping, has led to a lively debate as to whose task it should be to change the factors which are thought to work to the detriment of girls. If schools design intervention programmes with the intention of encouraging girls to choose to study mathematics, and the programmes are aimed at girls only, then they are expecting girls to shoulder the heavy burden of changing while still under the pressure of external forces.

Workshops which have been designed for several groups of people (parents, teachers, pupils, and counsellors) have met with some success. However, as illustrated by Hypatia, some females manage to overcome many of the pressures exerted on them and become competent mathematicians. It seems more reasonable, therefore, that intervention programmes should be intensive and focussed on those pupils most at risk. In order for this to be possible, teachers require the means to assess and identify those pupils in need. Further development of instruments to measure attitudes such as the cartoon method of the present study would help in the identification of the pupils at an earlier age than has previously been possible.

The raising of the school leaving age to sixteen years has forced pupils to remain at school until at least GCSE level and so the opportunity to encourage these pupils to study mathematics is easier than it might have been twenty years ago. If, as has been suggested by some educationalists, school leaving age is raised to eighteen and linked to industrial training, then maybe higher level mathematics could become accepted as a compulsory subject for some pupils, although this would seem rather extreme.

Given that change is necessary, the question remains as to what can be done. Workshop schemes with the aim of evoking change related to girls' performance in mathematics have, on the whole, concentrated on secondary age pupils. The present study, however, has shown that pre-school experience has already begun to operate on pupil attitudes and approaches to learning. Intervention at the pre-school age alone, but not at the secondary age, is unlikely to be particularly successful as illustrated by the Head Start programme. The Head Start programme of early intervention and compensatory education for young children from disadvantaged and ethnic-minority backgrounds found few lasting effects from participation in the programme (Bronfenbrenner,1974). Monitoring of pupils in order to identify the need for intervention would, therefore, need to be continuous.

In addition to the intensive focus on those pupils identified as being in particular need, is the need to focus on those factors which are small but so important that their effect is seen in later years. As demonstrated by the findings of the present study, the perception of gender as a factor of life is evident from at least as early as the lower junior age and, therefore, Inservice awareness programmes are required for all teachers, from the nursery age upwards, in order that they are informed of the situation and are provided with the possible means of monitoring and with instruction in attitude assessment techniques. While the acceptance of male and female sexes is a fact of life and must remain, male and female as gender affecting behaviour and performance should not. It is important therefore that school administration and organisation should not result in the emphasis of gender where there is no need e.g. in listing names for registration, splitting girls and boys in seating arrangements, etc. Many teachers believe the splitting of girls and boys names in the register to be an essential requirement of the LEA, and there is, therefore, a need for a directive from the directors of education to clarify the issue.

While various bodies have pressured publishers to ensure that text books do not contain sexist materials and drawings, the financial position of schools is such that whole sets of books cannot be changed immediately. Some sexism in literature will, therefore, remain in school libraries for some time. Because of this inevitability, it is even more important that the class teachers should attempt to redress any effect that the books might have. Constant monitoring and assessment should be part of the general assessment required of teachers as much as the national testing envisaged by the present government.

Inservice education is a means of helping teachers to be made aware of the issues related to gender and mathematical performance. However, all new entrants to the teaching profession should be made aware of the issues as part of their training. Initial teacher training courses should include the study of the effects of gender, not only gender generally, but also gender as it affects performance in each curriculum area and in particular mathematics.

Education of parents that they be made aware of the effect of gender stereotyping on performance in mathematics has already begun in some areas of the country, with many parents being involved in school workshops alongside their children. It is, of course, essential for parents of boys as well as girls to attend these workshops as the effect of stereotypical attitudes on boys will contribute to the general attitudes conveyed to girls, and which may subsequently affect girls' achievement levels in mathematics. As discussed earlier, children appear to have been influenced by parental and home experiences prior to the age of five. Awareness of gender effects on mathematics performance does, therefore, need to be made to parents long before the child reaches school age. Workshops with creche facilities is one answer, but attendance would be essentially voluntary. To educate all parents, therefore, gender awareness should be a compulsory part of the curriculum for all sixteen year old pupils, who will be the parents of the future generation.

The present study found that one of the most important factors which may prevent girls and low achiever boys from studying mathematics is the level of anxiety associated with the subject. The period between the second and fourth year juniors seems to provoke most change in pupil attitude, behaviour and performance, and this period coincides with an increase in the number of male teachers and an increase in more formal class teaching. There are two steps that can be taken. Firstly, more males need to be encouraged to enter the teaching profession of the nursery and infant age range. This would ensure that children become accustomed to working with either a man or a woman and not discriminate between them for learning purposes. Secondly, teachers need to reconsider the teaching style they employ. As whole class teaching does not appear to suit girls and low-achieving boys, then either these pupils should be segregated from high achieving boys, which would have the adverse effect of associating girls with low achievement, or teachers chould change to a more relaxed teaching style which would encourage all pupils to discuss mathematics quite openly. The present study found language to be an important determinant in ease/difficulty of test items and language development through discussion is therefore important for both girls and boys. If girls seem reluctant to respond to teacher questions, then active encouragement and use of praise should be employed. The teacher needs to be supportive. During all this, classroom teachers should be encouraged to partake in classroom research. With teachers as researchers, they can monitor their own behaviour, and the response they get from each of the pupils. The present study found boys to talk more about task than girls with the teacher and it is important for them to continue to do so, but it is also important for girls to talk about task from an early age in order to gain self-confidence in discussing task matters with the teacher. The mathematics classroom can be made a more sociable place, and mathematics learning seen as a cop-operative venture rather than one of competition. One of the first experiences children have of tests has often been the 'tables' test and this provokes feelings of anxiety from a very early age which subsequently becomes associated with mathematics.

The development of a method of error analysis on pupils work, in order to identify those pupils who fail to approach the teacher and hence develop their own often incorrect mathematical concepts, would be of particular use to teachers. If errors go unnoticed for too long, they become consolidated and unlearning is difficult to accomplish. The use of the computer could be of great value in some mathematics work as assessment and feedback can be immediate and thereby prevent consolidation of incorrect learning. Error analysis will also enable a teacher to assess if difficulty on a particular item is a mathematical conceptual one or one associated with language difficulty.

Once anxiety has been reduced and confidence increased from the primary years, then career advice and conventions showing male and females in non-traditional roles should encourage girls to be free of external forces which limit their career choice, and hopefully to result in more girls opting to follow mathematics to a high level of academic achievement.

9.3 Limitations of the Study

The present study attempted to investigate many of the variables thought to contribute towards the underachievement of girls in mathematics. By studying attitudes of teachers and parents, and performance and attitudes of pupils, with the same sample, the present study attempted to investigate the interrelations of these variables. While the study has been successful in several ways in this respect, the limitations of resources and time prevented more thorough investigation of each separate part.

The present study was initially designed to match male and female teachers in order to investigate the effect of teacher gender. However, only a few male teachers of infants could be found for participation in the study. While this in itself reflects the effect of gender on promotion prospects within education, it was disappointing that the effects of teacher gender had to be omitted in many parts of the study where it would otherwise have been considered an important aspect. The study was also limited to one LEA and the results could not, therefore, be generalised to other LEAs which are likely to have very different educational policies.

In order to investigate test responses of girls and boys, a classification system of errors was used to determine the frequency of language errors, conceptual errors, and others. Use of this classification system without additional information from interviews has led to a certain amount of conjecture in determining the strategies used by the children in solving a mathematical question. There are several possible reasons to explain omission of responses, particularly at the secondary age e.g. not understanding what the question requires, lack of time, lack of confidence in that particular topic. The error study was, therefore, limited in the extent of information it could offer.

The study of attitudes involved the development of an innovative method for use with young pupils with limited language skills. The method yielded some interesting and valuable results. However, use of the instrument for subjects other than mathematics would indicate whether the children's responses were related to the content of the drawing, particularly the mathematics on the blackboard, or whether the unfinished sentences themselves would have produced the same results. Development of the cartoon drawing for use with infant pupils was initially conceived such that infants compose their own picture and talk about it. An interview technique would have been essential with such a young age and the time and resources available were insufficient for such a study.

The availability of a large amount of data from the Oracle project was extremely useful in providing the opportunity for initial analysis. The results of this analysis pertaining to mathematics could then be studied in more detail in mathematics only lessons of the observation study.

The study of teacher attitudes was far from successful. Teachers were reluctant to answer questionnaires and the response was very poor. Given extra time and resources, it would be essential for a close working relationship to form with the teacher so that s/he could gain enough confidence to respond to the questionnaire. Alternatively, an interview technique would seem to be a preferred method at gaining teachers' thoughts about what appears to be such a sensitive issue.

9.4 Suggestions for Further Research

The results of the present study have constantly identified the period between the second and fourth year juniors to be important in the development of mathematics. Children changed in types of errors made in tests, changed in career aspirations, in levels of anxiety and motivation, and these changes were accompanied by an increase in the number of male teachers and the amount of whole class teaching experienced in mathematics lessons. As this age appears to be crucial to the development of mathematical concepts and attitudes which are necessary for the study of mathematics at a high level, intervention during or prior to this age would seem to be important in the prevention of underachievement of girls in mathematics. Further research is, therefore, required to investigate the forces at work during this crucial period. If the forces can be detailed, the information would be useful in determining the design of intervention programmes and assessment techniques which would be useful to the class teacher.

The present study has trialled an innovative technique for assessing pupil attitudes in young children, but further work is required. The recent report on assessment for the national curriculum commented on the importance of attitudes in pupil achievement but failed to recommend it as part of the national testing programme. While attitudes are notoriously difficult to measure, the extent of their effects on achievement should emphasise the need for research to overcome the problems and to develop a workable instrument.

Girls and low achiever boys do not appear to perform well in formal class teaching situations. Group work to encourage discussion by all pupils has been advocated as one means of developing confidence, particularly in girls. Very little empirical evidence is available to justify group work as an effective strategy for developing such confidence. Research is required to investigate the effect of grouping different personalities together; the effect on the quality of performance of the pupils in their discussion, practical and written work. In Leicestershire some work on the effect of grouping has taken place through means of the IT-Inset provision, but the investigation has been limited to one class whereas a wider study is required in order to determine the effectiveness of grouping in terms of it's contribution in increasing girls' confidence in mathematics.

Use of Inservice in which teachers attend courses at some educational centre and then return to their classrooms has proved to be relatively ineffectual with most teachers failing to put into practice what they learned on the course. More recent attempts to evoke change has been to take the inservice into the schools. Whole days have been set aside for staff development but the effectiveness of this form of inservice has not yet been evaluated. While an awareness of gender factors which influence pupil academic performance in mathematics may be sufficient to begin change in the classroom, whole school awareness and participation in self-appraisal of teaching method is necessary if children are to develop confidence and positive attitudes towards mathematics from the infant age upwards. Research in evaluating in-school inservice and methods of assessment and intervention is, therefore, required in order that the LEAs can develop an educational policy that will be beneficial to all schools in the area.

Intervention programmes for pupils has been discussed above, but there is also a need for intervention programmes with parents. Many schools have used workshops as a method of intervention for parents, but these workshops are essentially voluntary and their success depends on the willingness and cooperation of parents in attending. A wide research study on the timing and content of workshops would ensure that as many parents as possible could be reached. A workshop in the daytime is likely to prevent many parents from attending if they are at work. Similarly, many fathers may falsely assume daytime workshops to be designed for mothers. The issue of gender effects has proved to be a very sensitive issue and the advertisement and selling of these workshops need to be effective without causing antagonism.

The present study has provided some answers for the phenomenon of girls performing better than boys in the primary age in some research studies. The importance of language in determining the success of a pupil on a test item has been clearly evident. If mathematical concepts are to be tested divorced from a language influence then much further research is needed to find ways of developing mathematical language which is unambiguous and useful as wording for tests. Alongside this investigation would be a study of the later development of language skills in boys. If the rate of language development of boys can be accelerated then the number of boys who are able to study mathematics at high academic levels may increase.

The present study has been successful to some extent in its attempt to explain some of the gender differences in mathematics which have been reported over the years by several researchers. The phenomenon of a changeover of superiority of performance of girls and boys does not appear to be as remarkable as at first thought. Differences reported were inconsistent and the evidence suggests that late development of language skills in boys may account for superior performance of girls in the primary age. There is evidence that stereotype images affect pupil attitudes more strongly than actual experience and, therefore, demonstrates how seemingly insignificant events can accumulate and manifest at a later time. Investigation of girls' failure to choose to study mathematics at high levels even when their achievement is equal to that of boys has led to the suggestion that teachers should re-consider which teaching style should be employed and to investigate techniques for assessing and identifying those pupils most at risk from adverse attitudes and low levels of self-confidence. Only with the co-operation of teachers in facing the issue of gender and its effect on mathematical performance will the number of female mathematicians increase sufficiently to help alleviate the shortage of specialist mathematicians in this modern technological world.

APPENDIX I

THE LETTER SENT TO SCHOOLS AT THE BEGINNING OF THE STUDY

University of Leicester · School of Education
21 University Road, Leicester LE1 7RF · Telephone 0533 551122

Dear Headteacher,

As part of a research study at Leicester School of Education, it is proposed to conduct an observational study of 5 to 14 year old pupils inside the classroom. Enclosed is a sheet giving a brief background to the study which is concerned with sex differences in mathematics.

If it is convenient, I would be very grateful if I could come to talk to you regarding the possibility of your school participating in some way in this study. The classes observed over the various schools will, of course, need to be comparable and with this in mind I enclose a form which describes the particular classes required. I should be very grateful if you could find time to complete the form and return it to the School of Education in the envelope provided.

Thankyou for your attention, I look forward to hearing from you.

Yours sincerely,

Professors of Education: Gerald Bernbaum, Brian Simon, Derek Wright

SEX DIFFFRENCES IN MATHEMATICS.

Are boys generally better than girls at mathematics ? At C.S.E. and G.C.E. level more boys than girls gain a high grade pass and this gap widens at 6th form level. There are many studies which have revealed that boys do surpass girls in solving certain kinds of mathematical problems, especially of the more abstract kind (e.g. Eynard and Walkerdine, 1981).

As children leave primary school there's little or no difference in the measured performance in mathematics between the sexes. The differences tend to emerge somewhere between the ages of 11 and 15. Various explanations have been put forward for these differences, some believing that boys have a more natural mathematical ability, some believing that girls are subject to inhibiting social pressures. There may, of course, be several factors.

It is anticipated that some research will be done on the subject of sex differences with particular interest in the differences between attitudes and behaviour of children of primary school age (where no sex differences emerge), and of secondary school age (where the differences manifest themselves).

APPENDIX 1

FORM WHICH ACCOMPANIED THE LETTER TO THE SCHOOLS

Please complete the following :-

NAME OF HEADTEACHER ....

NAME OF SCHOOL ....

I am willing to discuss the possibility of allowing one or more classes in my school to be observed. YES/NO

The following range of classes are required for observation in the academic year 1982-83. If you think your school may be able to fit one or more of these, please tick the appropriate box.

	FEMALE TEACHER		MALE TEACHER	
	More than 5 years teaching experience	5 years or less teaching experience	More than 5 years teaching experience	5 years or less teaching experience
Reception Infants				
2nd year Junior				
4th year Junior				
2nd year Secondary				

APPENDIX 1 (Contd)

DETAILS OF THE TEACHERS INVOLVED IN THE STUDY

2nd Yr Juniors

TEACHER ID	EXPERIENCE	GENDER	CATCHMENT	SITUATION	TEST A BOYS	TEST A GIRLS	TEST B BOYS	TEST B GIRLS
10	High	fem	mixed	suburban	17	14	15	13
12	High	fem	middle	suburban	13	12	12	14
13	Low	fem	mixed	suburban	16	12	18	13
15	Low	fem	mixed	suburban	14	17	16	17
17	High	male	middle	suburban	7	4		
18	High	male	middle	rural	18	18	20	18
19	Low	male	working	suburban	12	16	20	16
20	Low	male	middle	suburban	12	15	10	13
TOTAL NUMBER OF PUPILS					109	108	111	104

4th Yr Juniors

TEACHER ID	EXPERIENCE	GENDER	CATCHMENT	SITUATION	TEST A BOYS	TEST A GIRLS	TEST B BOYS	TEST B GIRLS
22	High	fem	middle	rural	25	15	15	8
23	High	fem	mixed	rural	11	10	11	9
24	Low	fem	mixed	suburban	11	15	10	14
26	High	male	mixed	suburban	9	6	7	6
27	High	male	mixed	rural	14	14	13	13
28	Low	male	mixed	suburban	13	12	12	12
29	Low	male	middle	rural	13	14	12	15
30	Low	male	working	city	12	9	11	9
TOTAL NUMBER OF PUPILS					108	95	91	86

2nd Yr Secondary

TEACHER ID	EXPERIENCE	GENDER	CATCHMENT	SITUATION	TEST A BOYS	TEST A GIRLS	TEST B BOYS	TEST B GIRLS
31	High	fem	working	suburban	9	7	9	10
32	High	fem	mixed	suburban	17	13	16	13
33	Low	fem	working	suburban	10	5	12	7
34	Low	fem	mixed	suburban	17	6	12	5
35	Low	fem	mixed	rural	14	12	13	11
36	High	male	working	suburban	12	6	12	5
37	High	male	mixed	suburban	14	10	16	9
38	High	male	mixed	rural	13	8	13	9
39	Low	male	working	suburban	10	7	10	10
40	Low	male	mixed	rural	12	8	12	8
TOTAL NUMBER OF PUPILS					128	82	125	87

APPENDIX 2

INFANT TEST QUESTIONS

Practice

1. Show me the box with a spoon in it.
2. Show me the box with just one balloon in it.

Test

1. Show me the box with the tallest tree.
2. Show me the box which tells how many eyes you have.
3. Show me the box which is one less than 8.
4. Which clock has its big hand on number 6?
5. Which box has the boy sitting in the second chair?
6. Which box has the same number of balls on both sides of the line?
7. Which box has a square inside it?
8. If you had to put a number instead of the line, which box would you put the number 3 in?
9. Which box has the fewest things?
10. Which box has the right number to say how many balls it has got?
11. Which box has a triangle which is half blue and half white?
12. This is an empty bag, a telephone, a key and a spoon. Which would weigh the most?
13. Which number is one less than seven?
14. Which shape has only three sides?
15. Which shoe would fit into its box?
16. Point to number 8.
17. Which shape is cut into quarters?
18. Point to the box which has some corners.
19. What is one more than four?
20. Kay had 3 pencils and John gave her 1 more. How many pencils does she have altogether?
21. Which tells us what month it is?
22. Which glass is exactly 3 blocks tall?
23. If you had 3 balls and 1 rolled away, how many would you have?
24. Which clock says 8 o'clock?

APPENDIX 2 (Contd)

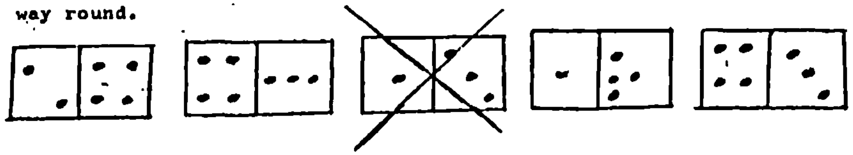
TABLE SHOWING THE NUMBER OF CORRECT AND INCORRECT RESPONSES FOR EACH ITEM OF THE INFANT TEST TOBE2

	BOYS			GIRLS			TOTAL		NO. OF PUPILS
Item	wrong	right	%	wrong	right	%	wrong	right	
1	3	76	.96	4	58	.94	7	134	141
2	2	77	.96	2	60	.96	4	137	141
3	49	30	.37	33	29	.47	82	58	141
4	10	69	.87	12	50	.81	22	119	141
5	19	60	.76	15	47	.76	34	107	141
6	31	48	.60	22	40	.65	53	88	141
7	6	73	.92	2	60	.97	8	133	141
8	26	53	.67	19	43	.69	45	96	141
9	44	35	.44	31	31	.50	75	66	141
10	13	66	.84	7	55	.89	20	121	141
11	31	48	.61	18	44	.71	49	92	141
12	6	73	.92	10	52	.84	16	125	141
13	37	42	.53	34	28	.45	71	70	141
14	11	68	.86	5	57	.92	16	125	141
15	31	48	.61	21	41	.66	52	89	141
16	4	75	.95	8	54	.87	12	129	141
17	72	7	.09	48	14	.23	120	21	141
18	43	36	.46	29	33	.53	72	69	141
19	34	45	.57	23	39	.63	57	84	141
20	23	56	.71	11	51	.82	34	107	141
21	8	71	.90	5	57	.82	13	128	141
22	29	50	.63	22	40	.65	51	90	141
23	17	62	.78	14	48	.77	31	110	141
24	10	69	.87	10	52	.84	20	121	141

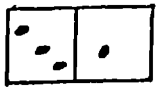
APPENDIX 2

PRACTICE TEST LEVELS 1 AND 3

1) In this row of shapes the piece with the cross on it is the wrong way round.

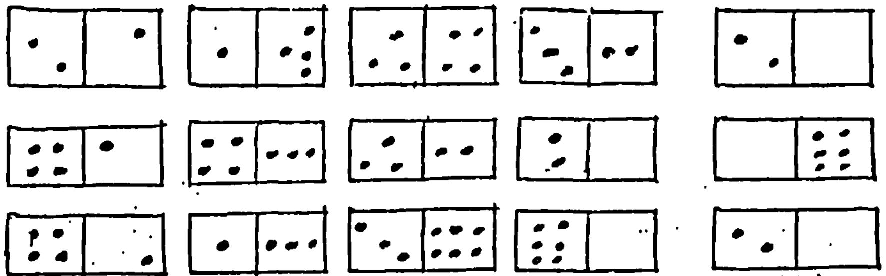


It should be like this :



so that the pieces next to it have the same number of dots on that side.

In each of the following rows, put a cross on the one piece which is the wrong way round.



2) These marks |||| can be made into a gate like this ~~||||~~

From 7 marks, 1 gate ~~||||~~ can be made leaving ||| marks over.

It is written like this

Marks	Gates	Left Over
7	1	3

For these marks, give the number of gates and the number of marks left over.

Marks	Gates	Left Over
6	____	____
8	____	____
3	____	____

3) 1 2 3 4 5 6 7 8 9 10 11 12

The number half-way between 5 and 7 is 6

The number half-way between 2 and 6 is 4

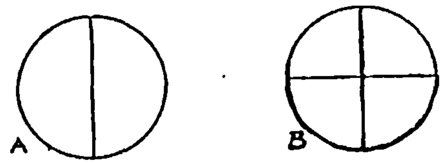
Write the number which is half-way between the two numbers :-

a) 4 8

b) 1 3

c) 3 9

4)



Circle A is the same size as circle B.

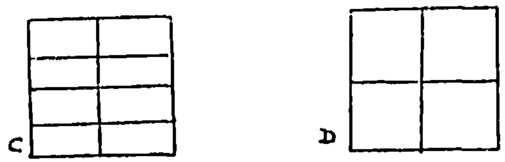
How many parts make up A ? ________

How many parts make up B ? ________

In A, if we want half the circle, how many pieces shall we have ? ______

In B, if we want half the circle, how many pieces shall we have ? ______

So, one part of A is equal to _____ parts of B.



4 parts of C is equal to _____ parts of D.

APPENDIX 2 (Contd)

DETAILS OF BRISTOL TEST SCORES

2nd Year Juniors

Test A 213 cases

	Mean	Min	Max	Stand Dev	Skewness
Number	15.7	1	25	6.4	-0.4
Reasoning	6.8	0	21	4.8	1.1
Space	5.8	0	14	3.5	0.26
Measurement	3.6	0	13	2.66	0.94
Arith Laws	9.0	0	15	3.51	-0.396
TOTAL	40.9	6	86	16.14	0.163

Test B 193 cases

Number	17.0	1	25	6.5	-0.7
Reasoning	9.3	0	24	5.4	0.65
Space	8.2	0	15	4.0	-0.25
Measurement	5.5	0	15	3.8	0.49
Arith Laws	9.8	1	15	3.56	-0.54
TOTAL	49.85	6	92	18.71	-0.093

8 pupils took best B but not test A
28 pupils took test A but not test B

4th Year Juniors

Test A 203 cases

	Mean	Min	Max	Stand Dev	Skewness
Number	14.9	1	20	4.7	-1.1
Reasoning	9.7	0	24	4.3	0.58
Space	7.5	1	15	3.3	0.056
Measurement	4.2	0	18	3.6	1.63
Arith Laws	2.8	0	7	1.7	0.43
TOTAL	39.1	9	70	13.2	0.26

Test B 181 cases

Number	14.57	0	20	4.6	-1.05
Reasoning	10.96	1	28	4.7	0.73
Space	7.5	0	15	3.3	0.29
Measurement	5.84	0	24	3.79	1.64
Arith Laws	2.98	0	9	1.94	0.87
TOTAL	41.83	13	89	13.98	0.58

12 pupils took test B but not test A
34 pupils took test A but not test B

APPENDIX 2 (Contd)

2nd Year Secondary

Test A 210 cases

	Mean	Min	Max	Stand Dev	Skewness
Number	8.65	0	23	6.2	0.40
Reasoning	6.78	0	19	3.99	0.78
Space	3.21	0	18	3.33	1.54
Measurement	0.90	0	9	1.37	2.08
Arith Laws	2.75	0	12	2.94	1.28
TOTAL	22.27	1	77	14.47	0.83

Test B 197 cases

Number	10.21	0	24	6.8	0.25
Reasoning	5.93	0	16	3.5	0.67
Space	3.42	0	16	3.46	1.26
Measurement	1.55	0	8	1.75	1.42
Arith Laws	2.46	0	11	2.85	1.04
TOTAL	23.57	0	66	14.77	0.61

28 pupils did test B and not test A
41 pupils did test A and not test B

APPENDIX 2 (Contd)

MEANS AND RANGE OF SCORES ON THE BRISTOL ACHIEVEMENT TEST

2nd Year Juniors
Test A

	Girls 106 cases			Boys 107 cases		
	Mean	Min	Max	Mean	Min	Max
Number	15.8	2	25	15.7	1	25
Reasoning	6.9	0	21	6.7	1	21
Space	5.6	0	14	6.0	0	14
Measurement	3.4	0	13	3.7	0	13
Arith Laws	8.9	1	15	9.2	0	15
Total	40.5	12	82	41.4	6	86

Test B

	93 cases			100 cases		
Number	16.7	2	25	17.3	1	25
Reasoning	8.9	0	24	9.7	1	22
Space	7.8	0	15	8.6	0	15
Measurement	5.0	0	14	6.0	0	15
Arith Laws	9.6	2	15	10.0	1	15
Total	48.1	6	92	51.6	6	86

4th Year Juniors
Test A

	Girls 96 cases			Boys 107 cases		
	Mean	Min	Max	Mean	Min	Max
Number	14.4	1	20	15.4	1	20
Reasoning	9.9	3	24	9.5	0	22
Space	7.4	1	14	7.6	1	15
Measurement	4.4	0	17	4.0	0	18
Arith Laws	2.6	0	6	2.9	0	7
Total	38.7	14	70	39.4	9	70

Test B

	88 cases			93 cases		
Number	15.0	2	20	14.1	0	20
Reasoning	11.5	2	23	10.4	1	28
Space	7.6	0	14	7.4	0	15
Measurement	5.7	1	20	6.0	0	24
Arith Laws	2.9	0	9	3.1	0	8
Total	42.7	16	85	41.0	13	89

APPENDIX 2 (Contd)

2nd Year Secondary

Test A

	Girls 82 cases			Boys 128 cases		
	Mean	Min	Max	Mean	Min	Max
Number	8.8	0	21	8.6	0	23
Reasoning	7.0	0	19	6.6	0	19
Space	3.0	0	16	3.3	0	18
Measurement	1.0	0	4	0.9	0	9
Arith Laws	2.6	0	11	2.8	0	12
Total	22.3	1	62	22.2	1	77

Test B	83 cases			114 cases		
Number	9.4	0	24	10.8	0	23
Reasoning	5.9	0	12	6.0	0	16
Space	3.1	0	14	3.7	0	16
Measurement	1.2	0	8	1.8	0	8
Arith Laws	2.4	0	10	2.5	0	11
Total	22.0	1	58	24.7	0	6

APPENDIX 2 (Contd)

MEANS AND RANGE OF SCORES OF PUPILS IN MALE AND FEMALE TEACHERS CLASSES

2nd Year juniors

Test A	113 cases Pupils of female teachers			100 cases Pupils of male teachers		
	Mean	Min	Max	Mean	Min	Max
Number	14.8	1	25	16.8	2	25
Reasoning	4.7	0	20	9.2	0	21
Space	4.7	0	14	7.0	0	14
Measurement	2.9	0	10	4.3	0	13
Arith Laws	8.2	0	15	10.0	0	15
Total	35.3	6	75	47.3	17	86
Test B	110 cases			83 cases		
Number	15.8	1	25	18.6	3	25
Reasoning	8.4	0	22	10.5	2	24
Space	7.3	0	15	9.3	0	15
Measurement	4.9	0	15	6.3	0	14
Arith Laws	9.4	1	15	10.3	1	15
Total	45.8	6	86	55.2	14	92

4th Year Juniors

Test A	Pupils of female teachers			Pupils of male teachers		
	Mean	Min	Max	Mean	Min	Max
Number	15.4	2	20	14.5	1	20
Reasoning	10.3	0	22	9.2	1	24
Space	8.0	2	15	7.1	1	14
Measurement	4.0	0	17	4.3	0	18
Arith Laws	2.8	0	7	2.7	0	7
Total	40.6	17	70	37.9	9	70
Test B						
Number	15.7	0	20	13.9	2	20
Reasoning	12.2	2	26	10.2	1	28
Space	8.8	3	15	6.7	0	14
Measurement	6.6	1	24	5.3	0	20
Arith Laws	3.4	0	8	2.7	0	9
Total	46.7	17	89	38.8	13	85

APPENDIX 2 (Contd)

2nd Year Secondary

Test A	110 cases Pupils of female teachers			100 cases Pupils of male teachers		
	Mean	Min	Max	Mean	Min	Max
Number	6.8	0	23	10.7	0	22
Reasoning	6.3	0	19	7.3	0	19
Space	2.9	0	18	3.5	0	16
Measurement	0.9	0	9	0.9	0	5
Arith Laws	2.8	0	12	2.7	0	11
Total	19.6	1	77	25.2	3	62
Test B	110 cases			87 cases		
Number	10.1	0	23	10.3	0	24
Reasoning	6.0	0	16	5.9	0	16
Space	2.8	0	12	4.1	0	16
Measurement	1.3	0	8	1.9	0	7
Arith Laws	2.1	0	11	2.9	0	9
Total	22.4	0	59	25.0	0	66

APPENDIX 3

THE PUPIL RECORD

DATE :

REF No :

Target's code letter:
Identification:
Base:Alone:2SS:2OS:SSS:SOS
Name: ....

Notes:

PUPIL-ADULT	1	2	3	4	5	1	2	3	4	5
1 INIT										
STAR										
PART										
LSWT										
2 TCHR										
OBSR										
OTHER										
3 TK WK										
ROUT										
POS										
NEG										
IGN										
4 IND AT										
GROUP										
CLASS										
OTHER										

PUPIL-PUPIL	1	2	3	4	5	1	2	3	4	5
5 BGNS										
COOP										
TRIES										
IGN										
SUST										
6 MTL										
CNCT										
VRB										
7a S TK										
D TK										
7b SS										
OS										
SEV SS										
SEV OS										
7c OWN BS										
OTH BS										

	1	2	3	4	5	1	2	3	4	5
8 COOP TK										
COOPR										
DSTR										
DSTR OBS										
DSRP										
HPLY										
WAIT TCH										
CODS										
INT TCHR										
INT PUP										
WOA										
RIS										
NOT OBS										
NOT LIST										
9 P IN										
P OUT										
P MOB										
P OUT RM										
10 T PRES										
T ELSE										
T MNTR										
T HSKP										
T OUT RM										

APPENDIX 3 (Contd)

T-TEST RESULTS ON THE EFFECTS OF PUPIL GENDER ON TEST SCORES OF 2ND YEAR PUPILS

Tchr Id	Variable		N	Mean	SD	SE	T	DF	Sig.
15	N	Grl	16	13.1	5.4	1.4	-2.5	28	0.18
		Boy	14	17.6	4.2	1.1			
15	M2	Grl	15	4.5	2.4	0.6	-2.2	27	0.04
		Boy	14	7.0	3.6	0.9			
18	N	Grl	18	18.5	4.2	1.0	2.1	34	0.05
		Boy	18	15.4	5.0	1.2			
18	R	Grl	18	12.1	4.6	1.1	2.3	34	0.03
		Boy	18	8.8	3.9	0.9			
18	A	Grl	18	11.1	2.3	0.5	3.0	34	0.01
		Boy	18	7.9	3.9	0.9			
18	TOT	Grl	18	54.1	10.2	2.4	3.0	34	0.01
		Boy	18	42.8	12.0	2.8			
18	R2	Grl	17	12.2	3.0	0.7	2.0	32	0.05
		Boy	17	9.6	4.3	1.1			

T-TEST RESULTS ON THE EFFECTS OF PUPIL GENDER ON TEST SCORES OF 4TH YEAR PUPILS

Tchr Id	Variable		N	Mean	SD	SE	T	DF	Sig.
26	N	Grl	14	15.4	2.5	0.7	-3.4	26	0.00
		Boy	14	18.2	1.8	0.5			
26	A	Grl	14	2.9	0.9	0.2	-2.6	26	0.02
		Boy	14	4.1	1.5	0.4			
29	R	Grl	14	12.6	4.1	1.1	2.5	25	0.02
		Boy	13	8.8	3.5	1.0			
29	M	Grl	14	7.1	5.2	1.4	3.3	25	0.00
		Boy	13	2.1	2.1	0.6			
29	R2	Grl	15	15.2	3.7	1.0	3.6	25	0.00
		Boy	12	10.4	3.0	0.9			
29	TOT	Grl	15	53.0	12.6	3.3	3.0	25	0.01
		Boy	12	40.2	8.5	2.4			

APPENDIX 3 (Contd)

T-TEST RESULTS ON THE EFFECTS OF PUPIL GENDER ON TEST SCORES OF SECOND YEAR SECONDARY PUPILS

Tchr Id	Variable		N	Mean	SD	SE	T	DF	Sig.
32	R2	Grl	13	8.2	2.7	0.8	-2.0	27	0.05
		Boy	16	10.7	3.8	1.0			
33	TOT2	Grl	7	13.1	8.1	3.1	-3.2	17	0.01
		Boy	12	23.8	6.4	1.9			
34	A2	Grl	6	0	0	0	-2.3	17	0.04
		Boy	13	0.8	0.9	0.2			
35	R2	Grl	11	7.0	1.4	0.4	3.7	22	0.00
		Boy	13	4.8	1.5	0.4			
36	S2	Grl	5	4.6	1.5	0.7	2.3	15	0.04
		boy	12	2.3	2.1	0.6			
39	A	Grl	7	0.2	0.4	0.1	-3.5	15	0.00
		Boy	10	1.3	0.8	0.3			

APPENDIX 3 (Contd)

T-TEST RESULTS ON THE EFFECTS OF TEACHER GENDER ON TEST SCORES OF 2ND YEAR PUPILS

Variable		N	Mean	SD	SE	T	DF	Sig.
N	Fem	113	14.8	6.6	0.6	-2.3	211	0.02
	Male	100	16.8	6.1	0.6			
R	Fem	113	4.7	3.4	0.3	-7.6	211	0.00
	Male	100	9.2	5.1	0.5			
S	Fem	113	4.7	3.1	0.3	-5.1	211	0.00
	Male	100	7.0	3.5	0.3			
M	Fem	113	2.9	2.2	0.2	-3.9	211	0.00
	Male	100	4.3	2.9	0.3			
A	Fem	113	8.2	3.6	0.3	-3.9	211	0.00
	Male	100	10.0	3.1	0.3			
TOT	Fem	113	35.3	15.0	1.4	-5.8	211	0.00
	Male	100	47.3	15.1	1.5			
N2	Fem	110	15.8	6.8	0.6	-3.0	191	0.00
	Male	83	18.6	5.9	0.6			
R2	Fem	110	8.4	5.4	0.5	-2.7	191	0.01
	Male	83	10.5	5.2	0.6			
S2	Fem	110	7.3	4.0	0.4	-3.6	191	0.00
	Male	83	9.3	3.8	0.4			
M2	Fem	110	4.9	3.6	0.3	-2.7	191	0.01
	Male	83	6.3	3.8	0.4			
A2	Fem	110	9.4	3.7	0.4	-1.8	191	0.08
	Male	83	10.3	3.3	0.4			
TOT2	Fem	110	45.8	18.8	1.8	-3.5	191	0.00
	Male	83	55.16	17.3	1.9			

APPENDIX 3 (Contd)

T-TEST RESULTS ON THE EFFECTS OF TEACHER GENDER ON TEST SCORES OF 4TH YEAR PUPILS

Variable		N	Mean	SD	SE	T	DF	Sig.
N2	Fem	69	15.7	4.4	0.5	2.6	179	0.01
	Male	112	13.9	4.7	0.4			
R2	Fem	69	12.2	4.5	0.5	2.7	179	0.01
	Male	112	10.2	4.7	0.4			
S2	Fem	69	8.8	3.3	0.4	4.5	179	0.00
	Male	112	6.7	3.0	0.3			
M2	Fem	69	6.6	4.4	0.5	2.3	179	0.03
	Male	112	5.3	3.3	0.3			
A2	Fem	69	3.4	2.1	0.3	2.6	179	0.01
	Male	112	2.7	1.8	1.7			
TOT2	Fem	69	46.7	14.1	1.7	3.8	179	0.00
	Male	112	38.8	13.1	1.2			

T-TEST RESULTS ON THE EFFECTS OF TEACHER GENDER ON TEST SCORES OF SECONDARY PUPILS

Variable		N	Mean	SD	SE	T	DF	Sig.
N	Fem	110	6.8	5.9	0.6	-4.9	208	0.00
	Male	100	10.7	5.9	0.6			
TOT	Fem	110	19.6	15.5	1.5	-2.9	208	0.00
	Male	100	25.2	12.6	1.3			
S2	Fem	110	2.3	2.8	0.3	-2.7	195	0.01
	Male	100	4.1	4.0	0.4			
M2	Fem	110	1.3	1.7	0.2	-2.3	195	0.03
	Male	100	1.9	1.7	0.2			

APPENDIX 3 (Contd)

VARIABLE MEANS FOR EACH CLUSTER FROM THE RE-ANALYSIS OF THE ORACLE MATHEMATICS DATA

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4
INIT	0.6	2.0	2.2	0.6
STAR	1.0	2.0	3.5	0.8
PART	5.8	27.1	3.7	6.8
TCHR	7.9	38.2	10.2	9.6
TKWK	6.4	32.5	7.7	7.6
ROUT	1.4	4.7	2.0	1.6
IND ATT	1.2	1.8	5.1	1.1
GROUP	2.7	5.1	1.3	1.3
CLASS	4.0	30.8	3.6	6.7
BGNS	9.3	3.6	5.0	3.7
COOP	8.3	4.3	6.2	4.3
MTL	2.2	0.5	0.5	0.5
CNTC	3.0	0.5	0.7	0.5
STK	27.5	10.7	9.6	7.5
SS	22.2	8.9	13.2	8.3
OS	3.5	1.9	1.7	1.6
SEVSS	6.2	0.7	2.0	0.7
SEVOS	2.6	0.9	0.9	0.9
OWNBS	29.7	10.4	13.3	10.4
COOPTK	52.7	64.3	50.1	66.7
COOPR	9.2	12.1	12.4	11.0
DSTR	26.9	12.1	15.3	11.2
WAIT TCH	2.7	4.2	14.1	3.0
CODS	2.0	1.9	1.2	0.9
INT TCH	1.1	1.8	1.9	2.1
INT PUP	3.6	2.3	3.9	3.6
PIN	91.4	93.0	72.7	91.4
POUT	6.0	6.0	23.5	6.0
PMOB	2.6	1.1	3.6	2.6
POUTRM	1.1	0.1	1.3	1.1
TPRES	14.7	44.7	20.3	14.7
TELSE	76.7	48.5	73.1	76.7
TMNTR	1.8	3.0	1.8	1.8
THSKP	3.4	2.5	3.6	3.4

APPENDIX 3 (Contd)

VARIABLE MEANS FOR EACH CLUSTER FROM THE RE-ANALYSIS OF THE ORACLE ENGLISH DATA

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4
INIT	1.5	1.1	0.8	1.6
STAR	3.3	1.1	1.0	1.7
PART	6.7	5.8	6.1	27.9
TCHR	12.4	8.9	8.8	35.1
TKWK	9.9	6.6	7.0	30.8
ROUT	2.1	1.8	1.7	4.2
IND ATT	4.4	2.0	1.4	2.3
GROUP	0.5	0.3	0.4	1.4
CLASS	7.2	6.6	6.2	32.3
BGNS	4.5	9.3	4.8	2.8
COOP	4.6	10.1	5.8	3.7
MTL	0.5	1.9	0.6	0.3
CNTC	0.7	3.0	0.9	0.6
STK	9.6	29.5	10.8	8.3
SS	9.3	24.7	11.3	7.0
OS	2.1	3.7	1.9	2.4
SEVSS	1.4	7.2	2.1	0.8
SEVOS	0.9	4.0	0.5	0.9
OWNBS	10.1	33.2	13.4	7.3
COOPTK	57.1	42.3	61.9	69.0
COOPR	12.6	10.5	9.9	10.9
DSTR	13.4	35.8	16.9	10.2
WAIT TCH	10.6	3.3	1.7	4.1
CODS	0.7	2.4	1.2	1.7
INT TCH	1.3	1.0	2.4	1.7
INT PUP	2.7	2.2	4.4	2.4
PIN	74.6	88.9	93.8	93.4
POUT	21.5	8.3	4.4	5.4
PMOB	3.6	2.9	1.8	1.3
POUTRM	1.0	0.8	0.3	0.4
TPRES	20.3	12.9	13.2	40.7
TELSE	73.1	77.0	72.2	48.5
TMNTR	1.6	3.1	5.1	6.7
THSKP	3.5	5.0	7.2	2.7

APPENDIX 3 (Contd)

VARIABLE MEANS FOR EACH CLUSTER FROM THE RE-ANALYSIS OF THE ORACLE TOPIC DATA

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4
INIT	2.2	1.1	0.7	2.1
STAR	1.5	0.9	0.7	2.9
PART	28.9	6.5	6.0	5.4
TCHR	38.6	9.4	8.3	10.9
TKWK	33.8	7.1	6.4	7.4
ROUT	4.1	1.9	1.7	3.3
IND ATT	1.4	1.7	1.0	4.4
GROUP	4.4	1.3	1.2	1.3
CLASS	32.4	6.6	6.0	5.3
BGNS	3.8	9.4	5.2	6.7
COOP	4.7	10.2	6.5	5.7
MTL	0.7	3.0	1.2	1.3
CNTC	0.5	3.0	0.8	1.1
STK	10.1	30.5	1.7	1.4
SS	9.4	24.8	11.9	13.5
OS	1.3	2.7	1.8	3.2
SEVSS	1.5	8.5	2.0	2.8
SEVOS	0.8	3.1	0.8	1.7
OWNBS	10.3	33.1	13.6	14.7
COOPTK	66.6	53.6	64.7	48.5
COOPR	12.8	10.4	12.1	18.5
DSTR	11.3	24.3	12.5	15.7
WAIT TCH	3.0	2.1	2.1	9.4
CODS	1.8	4.8	1.7	1.4
INT TCH	1.2	1.0	2.2	1.6
INT PUP	2.4	2.4	4.1	3.5
PIN	90.4	88.7	90.9	66.3
POUT	7.8	8.1	6.6	27.0
PMOB	1.6	2.8	2.4	5.7
POUTRM	0.6	1.2	0.4	2.3
TPRES	45.6	15.8	13.0	17.4
TELSE	47.5	68.0	70.3	75.6
TMNTR	1.6	1.3	5.0	1.0
THSKP	3.3	6.4	9.2	3.2

APPENDIX 3 (Contd)

VARIABLE MEANS FOR EACH CLUSTER FROM THE MATHEMATICS OBSERVATION

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4
INIT	4.8	1.5	1.0	1.1
STAR	3.8	2.1	1.9	2.0
PART	1.5	1.6	1.3	2.8
LSWT	3.1	3.0	3.7	29.5
TCHR	12.6	8.0	7.5	34.8
TKWK	10.1	6.4	6.5	34.3
ROUT	1.7	1.0	0.9	0.8
POS	0.3	0	0	0
NEG	1.2	0.7	0.4	0.1
IND ATT	8.2	3.0	2.3	2.3
GROUP	3.5	2.6	3.2	5.3
CLASS	1.5	2.5	2.5	27.8
BGNS	4.7	12.8	6.6	7.2
COOP	8.1	14.6	8.2	6.3
TRIES	0.5	0.3	0.5	0.6
IGN	0.2	0.4	0.1	0.1
SUST	1.5	4.8	1.0	1.2
MTL	2.3	4.4	2.0	1.6
CNTC	3.9	7.7	5.6	5.6
VRB	8.5	20.7	8.9	7.9
STK	12.9	31.0	15.1	15.2
DTK	1.8	1.8	1.3	0.2
SS	9.1	20.0	11.0	12.6
OS	3.1	6.4	3.3	1.0
SEVSS	2.2	3.0	1.0	1.4
SEVOS	0.3	3.5	1.1	0.3
OWNBS	11.1	26.5	13.8	13.3
OTHBS	3.4	6.4	2.6	2.0
COOPTK	43.1	43.1	58.3	67.6
COOPR	14.8	11.7	11.7	6.3
DSTR	15.1	28.0	14.8	14.3
HPLY	0	1.0	0.2	0
WAIT TCH	17.3	4.9	3.2	2.0
CODS	2.7	4.4	2.5	3.3
INT TCH	2.5	1.1	1.9	1.1
INT PUP	2.5	3.4	4.0	2.6
WOA	0	0	0.1	0.4
RIS	1.7	1.7	2.6	2.3
NOTOBS	0.4	1.1	0.2	0.1
PIN	65.6	84.2	91.2	95.6
POUT	30.6	10.3	5.6	8.1
PMOB	4.8	4.4	2.8	1.3
POUTRM	0.2	0.8	0.3	0.1
TPRES	30.4	15.0	17.9	49.0
TELSE	61.0	70.5	64.8	29.0
TMNTR	1.8	5.8	7.9	9.8
THSKP	2.4	4.7	6.6	5.1
TOUTRM	5.3	4.0	2.8	7.3

APPENDIX 3 (Contd)

PROPORTIONS OF PUPILS WITHIN EACH CLUSTER FOR EACH TEACHER

Tchr	Maths				English				Topic			
	1	2	3	4	1	2	3	4	1	2	3	4
102	0	1.0	0	0	.1	.6	.1	.1	.1	.5	.1	.3
112	0	.1	.9	0	0	.1	.9	0	0	.1	.9	0
113	0	.6	.4	0	0	.9	0	.1	0	.1	.9	0
121	.9	.1	0	0	.6	.1	.1	.1	.5	.5	0	0
122	.8	0	0	.2	.9	0	0	.1	.7	.1	0	.1
141	.1	.4	0	.5	.3	.3	0	.5	.4	.4	0	.2
152	.6	.3	0	.1	.3	0	.3	.3	.6	0	0	.4
153	.1	0	.1	.8	.6	0	0	.4	.4	0	0	.6
154	.4	0	0	.6	.4	0	0	.6	.4	0	0	.6
202	.1	.6	0	.3	.3	0	0	.8	.6	.3	0	.1
212	.3	.7	0	0	.4	0	.2	.4	.1	.1	.6	.1
231	.4	.1	.1	.3	.2	0	.5	.3	0	.2	.2	.7
272	0	0	1.0	0	0	.3	.6	.1	0	.4	0	.6
201	.1	.1	.5	.3	.1	.1	.4	.4	0	.1	.3	.6
202	0	0	.4	.6	.5	0	.5	0	0	.1	.6	.3
212	.4	.4	.3	0	0	.6	.1	.3	.3	.4	.3	.1
231	.3	0	.5	.3	0	.4	.6	0	0	.1	.6	.3
232	.4	0	.4	.3	0	.4	.5	.1	.6	0	.3	.1
233	.9	0	.1	0	0	.5	.5	0	.1	.1	.4	.3
234	0	.1	0	.9	0	.3	.1	.6	.1	.4	.1	.3
241	.3	.3	.3	.3	.3	0	.5	.2	.3	0	.7	0
242	.7	0	.1	.1	.2	0	.8	0	.1	.1	.6	.1
243	.3	0	.6	.1	.2	0	.8	0	.6	.3	.1	0
244	.1	0	.8	.1	0	.2	.8	0	.3	.1	.6	0
251	0	.2	.8	0	.1	.5	.3	.1	0	.6	.4	0
272	0	.2	.3	.5	.4	.1	.4	.1	.6	0	.4	0
201	.2	0	.4	.4	.1	0	.4	.5	.3	.1	0	.6
202	.5	.4	0	.1	.1	.1	.1	.4	.1	.4	0	.5
212	0	.4	.3	.3	.2	.3	.3	.2	.1	.8	.1	0
231	.4	0	.1	.5	.9	.1	0	0	.5	.3	.1	.1
232	.7	0	.1	.1	.6	.4	0	0	.7	0	0	.3
233	1.0	0	0	0	.1	.3	.4	.3	.1	.1	.7	0
234	.4	.1	.5	0	.5	.1	.4	0	.6	.1	.3	0
241	.3	0	0	.7	.1	.5	0	.4	.3	.3	0	.5
243	0	0	.3	.7	0	.2	.2	.7	0	.3	.4	.4
244	0	.3	.8	0	.1	0	.8	.1	.5	.3	0	.3
251	.5	.3	0	.2	.1	.6	.1	.1	.3	.1	.4	.1
271	.2	0	.2	.6	.1	.3	0	.6	.1	.1	.6	.1
272	.3	0	.2	.5	0	.1	.3	.6	0	0	.6	.4
273	.1	0	0	.9	0	0	.1	.9	.6	0	.1	.3
284	.5	0	0	.5	0	.3	.3	.4	.1	.4	.3	.1
301	.1	.8	.1	0	.6	.3	0	.1	.1	.9	0	0
302	.1	.4	.1	.4	.5	.1	0	.4	0	.6	.1	.3
311	.4	.1	.1	.3	.8	.3	0	0	0	1.0	0	0
312	.4	0	.3	.4	.1	0	.4	.5	.3	.4	0	.3
321	.4	.4	.3	0	.5	.3	.1	.1	.4	.4	.1	.1
322	.8	.1	.1	0	.5	.3	.3	0	.1	0	.5	.4

APPENDIX 3 (contd.)

PROPORTIONS OF PUPILS WITHIN EACH CLUSTER FOR EACH TEACHER (contd.)

Tchr	Maths				English				Topic			
	1	2	3	4	1	2	3	4	1	2	3	4
331	.2	.8	0	0	0	.3	0	.7	.1	.3	.4	0
341	.1	0	.9	0	.3	0	.8	0	0	0	.8	.3
351	.5	.3	0	.3	.4	.5	0	.1	.6	.4	0	0
352	0	.2	.3	.5	.4	.1	.4	.1	.6	0	.4	0
301	.3	0	.3	.5	.5	0	.5	0	.5	0	.3	.3
321	.3	0	.3	.3	.7	0	.3	0	.3	0	.7	0
322	.5	0	.3	.3	.8	0	.3	0	.8	0	0	.3
341	0	.5	0	.5	0	.8	.3	0	0	.5	.5	0
351	0	.8	.3	0	0	.8	0	.2	0	.5	.3	.2
352	0	.6	.2	.2	0	.8	.2	0	0	.4	.6	0
203	.3	0	0	.8	.1	0	0	.9	.6	.1	0	.3
204	.3	.3	0	.4	.4	.1	.3	.3	.1	.3	0	.6
211	.5	.3	0	.3	0	.4	.1	.5	.7	.3	0	0
235	.4	.3	.1	.1	.3	0	.6	.1	.1	.3	.4	.1
236	.3	.1	.5	.1	0	0	.3	.8	.6	.1	.1	.1
237	.1	.1	.7	0	0	0	.8	.3	0	0	1.0	0
245	0	.5	0	.5	.3	.3	0	.3	.4	.1	.1	.4
246	.3	.5	.1	.1	.1	.3	0	.6	0	.6	0	.4
248	0	.1	.3	.6	0	0	.6	.4	.3	0	0	.8
252	.2	.2	0	.6	0	.1	.9	0	.4	.1	.1	.4
253	.4	.3	0	.4	.3	.4	.3	.1	.6	.3	0	.1

APPENDIX 4

SIGNIFICANT T-TEST RESULTS ON THE DATA FROM THE OBSERVATION STUDY

INFANTS

by PSEX

Variable		N	Mean	T	df	Sig.
DTK	Boys	15	.0412	2.43	29	0.021
	Girls	16	.0081			
WAITTCH	Boys	15	.1095	-2.07	29	0.048
	Girls	16	.1850			

by TSEX

Variable		N	Mean	T	df	Sig.
BGNS	Boys	24	.0487	-3.29	29	0.003
	Girls	7	.1183			
TRIES	Boys	24	.0019	-3.11	29	0.004
	Girls	7	.0129			
MTL	Boys	24	.0330	-3.20	29	0.003
	Girls	7	.0694			
CNTC	Boys	24	.0325	-3.06	29	0.005
	Girls	7	.0742			
STK	Boys	24	.1273	-2.46	29	0.020
	Girls	7	.2170			
OWNBS	Boys	24	.1209	-2.74	29	0.010
	Girls	7	.2245			
CODS	Boys	24	.0144	-2.42	29	0.022
	Girls	7	.0455			

APPENDIX 4 (Contd)

SIGNIFICANT T-TEST RESULTS ON THE DATA FROM THE OBSERVATION STUDY

2ND YEAR JUNIORS

by PSEX

Variable		N	Mean	T	df	Sig.
ROUT	Boys	24	.0256	2.87	44	0.006
	Girls	22	.0074			
COOP	Boys	24	.0947	-2.53	44	0.015
	Girls	22	.1336			
VRB	Boys	24	.0965	-2.55	44	0.014
	Girls	22	.1479			
OTHBS	Boys	24	.0178	-2.02	44	0.049
	Girls	22	.0419			
WAIT TCH	Boys	24	.0478	2.11	44	0.040
	Girls	22	.0234			

by TSEX

Variable		N	Mean	T	df	Sig.
CLASS	Boys	24	.0230	-2.07	44	0.045
	Girls	22	.0952			
COOPTK	Boys	24	.5525	2.72	44	0.009
	Girls	22	.4528			
TMNTR	Boys	24	.0902	4.97	44	0.000
	Girls	22	.0305			

APPENDIX 4 (Contd)

SIGNIFICANT T-TEST RESULTS ON THE DATA FROM THE OBSERVATION STUDY

4YR JUNIORS

by PSEX

Variable		N	Mean	T	df	Sig.
WAIT TCH	Boys	24	.0515	2.04	46	0.047
	Girls	24	.0160			

by TSEX

Variable		N	Mean	T	df	Sig.
ROUT	Boys	18	.0186	2.60	46	0.013
	Girls	30	.0038			
COOPR	Boys	18	.1403	2.70	46	0.010
	Girls	30	.0902			
INT TCHR	Boys	18	.0044	-2.46	46	0.018
	Girls	30	.0166			
PIN	Boys	18	.8327	-2.05	46	0.046
	Girls	30	.9108			
PMOB	Boys	18	.0454	2.44	46	0.019
	Girls	30	.0225			
THSKP	Boys	18	.0357	-2.03	46	0.048
	Girls	30	.0714			

APPENDIX 4 (Contd)

SIGNIFICANT T-TEST RESULTS ON THE DATA FROM THE OBSERVATION STUDY

SECONDARY

by TSEX

Variable		N	Mean	T	df	Sig.
PART	Boys	30	.0242	2.20	58	0.032
	Girls	30	.0107			
NEG	Boys	30	.0131	2.20	58	0.032
	Girls	30	.0034			
CNTC	Boys	30	.0690	2.21	58	0.031
	Girls	30	.0377			
THSKP	Boys	30	.0752	2.20	58	0.032
	Girls	30	.0438			

ETHNIC MINORITY

by TSEX

Variable		N	Mean	T	df	Sig.
CNTC	Boys	10	.0900	3.01	25	0.006
	Girls	17	.0118			
OWNBS	Boys	10	.1600	2.08	25	0.048
	Girls	17	.0765			
OTHBS	Boys	10	.0100	-2.41	25	0.024
	Girls	17	.0765			
COOPR	Boys	10	.2200	2.69	25	0.013
	Girls	17	.0294			
TELSE	Boys	10	.7200	2.10	25	0.046
	Girls	17	.4353			
THSKP	Boys	10	.0600	2.12	25	0.044
	Girls	17	.0118			

APPENDIX 5

THE SECONDARY PUPILS' QUESTIONNAIRE

1. I do as little in maths as possible. SA A U D SD
2. My father is very interested in maths. SA A U D SD
3. I'm just no good at mathematics. SA A U D SD
4. When a woman has to solve a maths problem it is feminine to ask for help. SA A U D SD
5. My maths teacher makes maths seem boring. SA A U D SD
6. I don't need maths for my future career. SA A U D SD
7. My Mother has strongly encouraged me to do well in maths. SA A U D SD
8. I'd be proud to get top marks in a maths test. SA A U D SD
9. Maths is enjoyable and stimulating to me. SA A U D SD
10. I would feel embarrassed to get top marks in a maths test. SA A U D SD
11. My Mother would never discuss a maths problem with me. SA A U D SD
12. Maths is very useful. SA A U D SD
13. My maths teacher makes maths interesting. SA A U D SD
14. Boys have a natural ability for maths, girls don't. SA A U D SD
15. My progress in maths is unimportant to my father. SA A U D SD
16. I'm a nervous wreck during a maths test. SA A U D SD
17. I feel quite at ease with a maths problem.
18. I am quite good at working out maths problems. SA A U D SD
19. I get out of doing maths whenever possible. SA A U D SD
20. I try and try but maths still seems very hard for me. SA A U D SD
21. I feel at ease doing maths. SA A U D SD
22. My Father has encouraged me to study more maths. SA A U D SD
23. Women are just as good as maths teachers as men are. SA A U D SD
24. My maths teacher never praises me when I do good work. SA A U D SD
25. Maths can be forgotten when we leave school. SA A U D SD
26. My progress in maths is unimportant to my Mother. SA A U D SD
27. I would hate to be top of the class in maths. SA A U D SD
28. My Mother thinks that maths is one of the most important subjects I have studied. SA A U D SD
29. I shall use maths a lot in my daily life as an adult. SA A U D SD
30. My maths teacher knows a lot about maths. SA A U D SD
31. Girls often do as well or better than boys in maths. SA A U D SD
32. My Father thinks I have no need for maths. SA A U D SD
33. Working maths problems is fun. SA A U D SD
34. I can do my maths homework by myself. SA A U D SD
35. I'd feel proud to score highly in maths. SA A U D SD
36. When I hear the word maths, I have a feeling of dislike. SA A U D SD

APPENDIX 5

A FULL LIST OF CARTOON COMBINATIONS FOR THE ATTITUDE STUDY

All boys group in foreground :	Male Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy
:	Fem. Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy
All girls group in foreground:	Male Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy
	Fem. Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy
Mixed Group in foreground : (2 versions)	Male Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy
:	Fem. Teacher	Sitting with the group Standing in front of the class Standing with a boy and girl Standing with a girl and boy

APPENDIX 5 (Contd)

CODING CATEGORIES FOR THE CARTOON METHOD OF STUDYING ATTITUDES

1. Inform or reply about routine matters.

I can't find my pen/pencil
Please take your coat away
Get your books out
There is a page missing
Go and stand by my desk
Here comes the teacher
I do not know (where the rubber is)
Let's do it in a group
Nor have I got a piece of paper
I'll let you go first, Suzy
No way will I give it back
I've forgotten my pencil
I need a new book
Get some paper for the test
Here you are (the rubber)
I think I will sharpen my pencil
Put everything down
Go to dinner
Give it back
No you can't (borrow the rubber)
I haven't got a piece of paper
Here's a piece of paper
Give my ruler back
Pack away please
No, do not get the clocks
I want your paper

2. Enquire about a routine matter.

Put your hands up all those who are going swimming tomorrow.
Can I borrow your pencil/rubber/ruler?
Could you pass the pencil/maths book?
Have you got a spare pencil?
Can I get a book/sharpen a pencil?
Where is the clock?

3. Inform or reply - non-task routine.

I will be good today
Let's throw a rubber at teacher
I'm going to my grandmother's
I like you
The film was good last night
Let's play hide and seek
Happy Birthday
Good Day/Morning
I've got a toy car in my desk
The school bell has gone
Let's play with the Lego
You're my best friend
I am the best boy
A good game of football
I cannot wait for dinner
I'm playing rugby tonight
Thankyou
I've got a new dress
Because I feel like it
It's past 3, O.K.?

APPENDIX 5 (Contd)

4. Related to difficulty/dislike of task.

I can't do this work
I don't understand maths/circles..
These maths are hard
I don't like this

This is boring
Oh no, not this again
It looks too hard for me
I've gone wrong
I hate this subject
Oh no, I'm rubbish at this
How on earth do you do that
This is hard work

I do not know how to do this sum
I got mine all wrong
Oh dear, I am very stuck
I don't think I am sure how to do this

I don't get this
This is strange
Miss, this thing's stupid
I'm tired
Can you help me, I'm stuck
Look at them hard sums
I do not like this, do you?

5. Enquire - non-relevant.

Have you seen E.T.?
Are you playing tonight?
Do you want to come to my house?
Shall we play on bikes today?
Can I go to the toilet please?

Can I play with you at dinner?
What's the time?
Are you going to the party?
Can you bring your doll round?
Hello Susan, how are you today?
When is it time to go out?

Shall we mess about?
Playing football tonight?
Is it time to go out yet?
What are you going to do at play?
I wonder what we're having for dinner

Shall we have a scrap?
Will you go out with me?
Where did that come from?
Are you going to have a fight?
When will we go home?
Do you like my hair band/nails?

6. Praise Behaviour.

Donna is good

7. Related to ease/liking or completion of task.

It is easy/simple/sinch
I've finished already
I know how to do it, I'll tell you
This is great

Oh goody!
I'm very clever, I've finished
This is fun

I know the answer to this
This is easy, I want some more
I like doing this
I already know what the teacher means

I like maths, it's good
These maths are good

APPENDIX 5 (Contd)

8. Provide non-factual information - task related.

Look at the blackboard/me/the walls
Will you do this in your book
Get out your maths book
Hurry up children
I will tell you a story
I'll come and show you
Because you learn things
Just have a go
I like to do English
You have 5 mins to do this
No, come here
PE is tomorrow
Work it out yourself
Let's mark the maths on the board
Now listen
Because of your education children
The answer is ...
Go and get your maths/English
I hope it's RTSP
This is what you do
Now look at the work on the walls
I'm going to write it out neat
After this we do handwriting...
It's break time
Carry on working
Ask the teacher
I'm going to draw
Put it in your books
It's maths, Jane
I will explain it again
The teacher wants us
Do you do it in pencil?
You can start now
Sets 2,4,6 do maths
Write down....

9. Corrective - related to behaviour.

Go and stand by the wall for talking in a lesson
No you can't go and sit down
Stop kicking me
Jonathan sit on four legs
Stop showing off or I'll give you harder ones to do
Shut up or you will get told off
Stop that at once
Shut up you're disturbing me
You're a pest
Stop being silly
Miss that boy is biting me
Pack/stop talking
Who is talking?
Listen to me when I'm speaking
Put your fingers on your lips
Stop squabbling you two
Quiet grubby oafs
Oh shut up you naughty children/ silly boy/ or I'll hit you
Be quiet you noisy lot
Don't chatter or...
Stop whispering/moving your chair
Come on class/boys and girls
Stop boasting clever clogs
You're supposed to be working
For goodness sake be quiet Darren
This is the 3rd time I've had to..
What is going on over there?
Pay attention
You're silly
Sh.Sh!
Come here boys
Close your lips
Please be quiet for a minute
Work in silence please
Take 1000 lines

APPENDIX 5 (Contd)

10. Ask for factual information - task.

What's the answer?
What are sets?
What is 12 times 10?
I need some help
Do you know the answer
Let's copy you
What is it then?
How do you get 6 as the answer
Why do you draw the circles?
How do you spell...?
How do you do this work?
What is this sum?
Please miss, help me
How is it done?
Why are there circles there?
Can you explain this?
What does that mean?
Which number can be added?
Tell me the connection between...

11. Provide factual information - task.

One of the girls is saying the answers
1+2=2, 2+2=4...
Yes, no, yes, no, yes
The answer is 16
And then you write 9
I will help you with the sum
Look this is how to do it
Add them up
A circle has two numbers
That one goes in there
Copy me

12. Praise task work.

You are both right
Your writing is very neat
Yes, the answer is 36, good girl
You must be brainy
Good work
That is right
That is interesting and correct
Well done
That is neat
Good writing

13. Corrective - related to task.

I've told you enough times - bring your work here
Just get on with it
Look at the board, silly
The teacher's only just told us
Don't copy
It is not!
You should improve your work
Your work is really messy
Of course not
Look and you will learn!
You can do it, now get on with it
You've done it wrong

APPENDIX 5 (Contd)

14. Other - task related.

One of the girls is saying something that the teacher asked her
One of the boys is saying something about sets
The girl is saying something about her work
Pardon/ yes miss
The teacher is saying if they have got it right
The boys is saying lets look in the dictionary
The teacher is saying I hope the class like the work
What one? Oh! 63 divided by 7
What do you mean I have finished
The boys said something to his friend
You lucky thing

15. Ask for non-factual information - task.

What's new Teacher?
Do we have to do this?
Can I make....?
Is Mr - going to teach football?
What's the matter Mark?
Do you need help?
What are you doing?
Is this O.K.?
What don't you understand?
Can I help her?
When are we have PE?
How many do you have to do?
How long have we got?
What shall I do?
Can I choose please?
Can I use the blocks?
What's she talking about
Why do we go to school?
What is it?
Can you do it?
Do you understand?
Have you done this before?
What do you think of this, Sue?
Do we do this in our maths book?
What group am I in Sir?
How many have you done?

16. Corrective on routine/nastiness/scorn.

Get lost big-head
I'm going to get you tonight, Tim
Wait and she will tell us Dippy
I'll beat you in at play
I do not like you
You're the teacher's pet!

Why should I tell you?

Let's beat him up
Watch your lip
Ha look at that boy
I'm going to fight you
I hate you
Ha ha she doesn not know how to do it

You're a pest

17. Comradeship

Never mind, I'll help you
Don't listen to him
Don't be shy

You can copy me if you like
It's not your fault, you'll do better next time

APPENDIX 5 (Contd)

SIGNIFICANT CHI-SQUARED RESULTS OF THE SHORT CARTOON ATTITUDE STUDY

Variable	with	Sentence No.	χ^2	df	Sig
AGE		1	9.25	2	.0098
AGE		2	11.24	2	.0036
SCHOOL BACKGROUND		1	14.19	4	.0067
SCHOOL BACKGROUND		2	15.85	4	.0032
SCHOOL BACKGROUND		3	9.59	4	.0479
AREA		1	10.32	4	.0354
AREA		2	13.83	4	.0079
AREA		3	9.95	4	.0412
TSEX		2	8.71	2	.0129

APPENDIX 6

TEACHER QUESTIONNAIRE

Please underline all the words which describe how you feel towards mathematics.

DISLIKE DISINTERESTED HATE LIKE ABLE CALM ANXIOUS CONFIDENT
DISTRESSED ENTHUSIASTIC MATTER-OF-FACT CHEERFUL SCARED STIMULATED
STRUGGLING SMART SUCCESSFUL FAILURE CONFUSED ILLOGICAL
COMFORTABLE PANIC PLACID WORRY
HELPFUL MUNDANE UNIMPORTANT ESSENTIAL USEFUL UNNECESSARY
RELEVANT IMPORTANT IRRELEVANT FORGETTABLE FEMININE UNSURE
MASCULINE BORING CHALLENGE FUN WASTE DIFFICULT EASY

Please underline all the words which describe how you feel towards teaching mathematics.

HAPPY CONFUSED ENTHUSIASTIC DISTRESSED ABLE CALM CONFIDENT
STIMULATED SUCCESSFUL FAILURE UNSURE ANXIOUS STRUGGLING DISLIKE
HATE
BORING FUN CHALLENGE MUNDANE

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

If you have any further comments to make please do so here :-

If you have no objection please answer the following :-

a) In what year did you complete your teacher training ?

b) What are your specialist subjects ?

c) Are you a graduate ?

d) What is your age ? 21-25 26-30 31-35 36-40 41-45 46-50 over 50

e) Please state your name. ______ Your gender male / female

APPENDIX 6 (Contd)

FACTOR RESULTS OF TEACHER QUESTIONNAIRE

FACTOR	EIGENVALUE	% OF VARIANCE
1	14.56	24.7
2	7.70	13.1

FACTOR MATRIX

Variables of teacher's feelings towards mathematics	FACTOR 1	FACTOR 2
DISLIKE	.38	.52
DISINTERESTED	.52	-.42
HATE	.73	-.20
LIKE	.05	.81
ABLE	.31	.27
CALM	.43	.40
ANXIOUS	.39	-.60
CONFIDENT	.31	.51
DISTRESSED	.96	-.01
ENTHUSIASTIC	.19	.53
MATTER-OF-FACT	.39	.05
CHEERFUL	.23	.52
SCARED	.04	-.24
STIMULATED	.29	.63
STRUGGLING	.45	-.29
SMART	.96	-.01
SUCCESSFUL	.50	.42
FAILURE	.73	-.20
CONFUSED	.42	-.43
ILLOGICAL	.76	-.14
COMFORTABLE	.33	.35
PANIC	.73	-.08
PLACID	.46	.33
WORRY	.39	-.49
HELPFUL	.22	.34
MUNDANE	.11	-.18
UNIMPORTANT	.96	-.01
ESSENTIAL	.13	.11
USEFUL	.09	.26
UNNECESSARY	.96	-.01
RELEVANT	.17	-.02
IMPORTANT	.18	.33
IRRELEVANT	.96	-.01
FORGETTABLE	.53	-.32
FEMININE	-.06	-.03
UNSURE	.50	-.43
MASCULINE	-.06	-.03
BORING	.96	-.01
CHALLENGE	.14	.60
FUN	.24	.51
WASTE	.96	-.01
DIFFICULT	.38	-.32
EASY	.39	.13

APPENDIX 6 (Contd)

Variables of teachers' feelings towards the teaching of maths	FACTOR 1	FACTOR 2
HAPPY	.13	.34
CONFUSED	.06	-.37
ENTHUSIASTIC	.13	.56
ABLE	.23	.27
CALM	-.04	.41
CONFIDENT	.26	.55
STIMULATED	.37	.32
SUCCESSFUL	.37	.26
FAILURE	.96	-.01
UNSURE	-.01	.52
ANXIOUS	.37	-.47
STRUGGLING	-.03	-.46
DISLIKE	-.01	-.42
FUN	.22	.38
CHALLENGE	.17	.17
MUNDANE	.96	-.01

APPENDIX 6 (Contd)

PARENTS QUESTIONNAIRE

Please underline all the words which describe how you feel about mathematics.

DISINTERESTED LIKE ABLE STRUGGLING CALM CONFIDENT ANXIOUS
FAILURE SCARED ENTHUSIASTIC ILLOGICAL SUCCESSFUL CHEERFUL
DISLIKE DISTRESSED UNSURE CONFUSED SMART MATTER-OF-FACT
STIMULATED PANIC PLACID HATE WORRY COMFORTABLE
ESSENTIAL BORING USEFUL MASCULINE UNNECESSARY WASTE EASY
FUN IRRELEVANT DIFFICULT FEMININE IMPORTANT RELEVANT CHALLENGE
FORGETTABLE HELPFUL MUNDANE UNIMPORTANT

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

Please underline all the following words which describe how you would feel supposing ______________ was exceptionally bright at mathematics.

MARVELLOUS EMBARRASSED HAPPY CONSPICUOUS PROUD UNSURE
WARY ENCOURAGE HELP WASTE DISCOURAGE

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

Please underline the words you think describe how _______ feels about mathematics.

CALM ANXIOUS CONFIDENT DISTRESSED ENTHUSIASTIC MATTER-OF-FACT
SCARED ENJOYS STIMULATED STRUGGLING SMART SUCCESSFUL FAILURE
UNSURE ABLE CONFUSED DISLIKE INTERESTED HATE CHEERFUL ILLOGICAL
BORING CHALLENGE USEFUL UNNECESSARY RELEVANT WASTE
IMPORTANT FORGETTABLE

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

Please state whether you are the Mother or Father ____________

If you have no objection please state your occupation ______________

If you have any comments to make please do so here :-

APPENDIX 6 (Contd)

SIGNIFICANT CHI-SQUARED RESULTS OF THE PARENT ATTITUDE STUDY

Variables		χ^2	df	Sig
SELF-CONCEPT	with SEX OF PARENT	53.55	10	.000
ANXIETY	with SEX OF PARENT	34.26	10	.000
PARENT'S VIEW OF CHILD'S SELF-CONCEPT	with SEX OF PUPIL	36.12	8	.000
PARENT'S VIEW OF CHILD'S SELF-CONCEPT	with AGE	41.15	24	.016
PARENT'S VIEW OF CHILD'S ANXIETY	with AGE	33.56	18	.014
PARENT'S VIEW OF CHILD'S MOTIVATION	with SEX OF PUPIL	12.62	6	.049
PARENT'S VIEW OF CHILD'S PERCEPTION OF THE USEFULNESS	with AGE	61.49	15	.000

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