Primary children's perception of science and scientists

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Abstract

Primary children's perceptions of science and scientists have been relatively less studied than similar perceptions of secondary school students. The perceptions of younger children may be important, as, in combination with their later experiences, they may affect students' decisions in respect of studying science at higher levels.

With the advent of the National Curriculum for Science, primary school children now have access to a broader base of science study. Children in state schools aged 9 years old (Year 5), have had all their science experience under the aegis of the National Curriculum. In this study, the perceptions of boys and girls in different types of schools were compared, to identify any differences in their perceptions of science and scientists. The schools in the study comprised, mixed state schools, mixed independent schools and single sex independent schools. The children drew a scientist, completed a questionnaire and performed three scientific tasks to assess their perceptions of science and scientists. The tasks were selected to be of female, male and neutral orientation.

The study found that the children's perception of scientists was different from that found by other studies of the perceptions of scientists of younger children, in that more girls are likely to perceive a scientists as being female. This was particularly the case in single sex girls' schools. The children were less positive about scientific experiments than has been found previous studies and in comparison with 11 year old (Year 8) secondary school entrants. The division of the sciences, namely that physics is more of a male subject, appears to still be prevalent, particular amongst boys in boys only schools.

PRIMARY CHILDREN'S PERCEPTION OF SCIENCE AND SCIENTISTS

MASTER OF ARTS THESIS

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Declaration

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Statement of Copyright

Chapter 1

Introduction

> *" the scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses.....he may wear a beard... he is surrounded by equipment"*
>
> *Chambers 1983 p256*

Thus the public stereotype of the scientist is expressed. This impression of a stereotypical image emerged as a result of the work of Margaret Mead and Rhoda Metraux in the 1950's (Mead and Metraux 1957) and may still hold today. It would be interesting to discover the extent to which this image is actually held particularly in children. The intervening forty five years have seen many changes in the field of science. There have also been many attempts to change the public image of science and the attitude of secondary school students to the study of science.

The advent of the National Curriculum has meant that, now as never before, primary school children are expected to study science as a descrete subject. If the puplic stereotype of science and scientists has been thought to effect secondary school pupils' attitudes to science, then it is reasonable to expect that primary children's perception of science and scientists may have an effect on their attitude to the science they are now required to study. Little is know about primary childrens' perception of science and scientists other than a few studies and extrapolation backwards from what is known about secondary school pupils perceptions.

The Mead and Metraux (1957) study was undertaken as a result of concern with regard to the lack of uptake of science and engineering courses by American students. The American Institute for Science Education had spent a large amount of money raising the awareness of the students about science and careers in science and engineering. They realised that they did not understand clearly what the students' actual perceptions of science or scientists were. That there was a stereotypical image of the scientist seemed not in dispute (Mead and Metraux 1957), but the exact nature of the stereotype had not been previously investigated to any extent. The popularity of novels such as Jekyll and Hyde (Robert Louis Stevenson 1875) and Frankenstien (Mary Shelley 1811) gave one interpretation of an aspect of scientists and their work, largely fantastic and terrifying. These novels can be said to have helped to establish a public, stereotypical image that had already gained credence through the centuries, that of a man in a white coat at work in a laboratory.

The image of the scientist as someone involved in contentious activities, such as those of Dr. Frankenstien, is not entirely new. Early scientists and philosophers, such as Galileo, Aristotle, Copernicus and Ptolomy, were provoking disputes with religious authorities and other leading figures in society, hundreds of years ago, as they extended the boundaries of scientific knowledge. Since then, scientists and their work have continued to come into conflict with society, particularly in areas of long held religious beliefs. Charles Darwin published 'The Origin of Species'(1859), outlining his biological theories. This work introduced the idea of genetic evolution through natural selection, dependant on habitat. The popular interpretation of his work by the media, led to assumptions that humans had evolved from other animals, rather than being created by God, and thus caused conflict with religious authorities. At that time 70% of the country's schools were under the aegis of the Church (Cox and Taylor 1983). This conflict resulted in a set back for what little science education already existed in schools for many years, as the Church refused to countenance such teachings in their schools. Modern scientific discoveries, such as cloning and genetic engineering, whilst working for the benefit of mankind, also fire the imagination of the general public and the novelists and film makers who feed this imagination. Many scientists who have made ground breaking discoveries remain little known outside their own field, their work being quietly assimilated and accepted into the general scheme. A few have made their way into the realms of folklore. For example, Sir Isaac Newton's work on gravity is associated with falling apples, though this was only a very small part of his work. His portraits portray him as a sober gentleman. Albert Einstein on the other hand, appears to be increasingly portrayed as small and bespectacled with eccentric speech and mannerisms and a mop of unruly grey hair. His discoveries, which have led to modern developments in space science, are little known beyond his much quoted formula, $E = mc^2$, though it is doubtful if all those who quote it can explain the meaning.

The American Institute for Science, was concerned that despite initiatives employed to encourage students to take up science courses and careers, there was in fact, a steady decline in the uptake of science and related careers by students. Mead and Metraux (1957) were commissioned to investigate possible reasons for this and concentrated on the image of science and scientists held by students, in order to investigate and clarify what was known of the students' perceptions in these areas. Their results crystallised the image in the form that has become generally accepted as representing the essence of the public stereotypical image.

Over recent years there have been moves to dispel this public stereotype, which is thought to be, in part, responsible for the decline in interest in science generally and the rejection of science by some women and girls, in particular. The initial impetus came from the seminal study of Margaret Mead and Rhoda Metraux in 1957, when they identified the public image of science. The views expressed by the participants in the research project have formed the basis for much further research, which will be dealt with in detail later.

There are two factors that arise from the Mead and Metraux (1957) study. Firstly, there appears to be a public image of a scientist as a personality and secondly, this image is generally expressed as being male which possibly affects the perception of girls and women with regard to science.

About the same time as the Mead and Metraux (1957) study in America, concerns were being expressed about the nature of science teaching in British schools. Ways of improving pupils' performance and participation in science courses were being considered, with particular emphasis on interesting girls in science. This was thought to be appropriate in the light of the public stereotypical image of the scientist which had emerged from the research. These initiatives placed a strong emphasis on appropriate practical experiments, later highlighted as of critical importance by the Plowden Report (CACE 1967) and included in the Nuffield 5 - 16 project. It was thought that if science could be made relevant to all participants, then their interest would be maintained.

More recently further initiatives have aimed at addressing problems of participation in science. The emphasis on the practical aspects of science put forward by the Plowden Report and the Nuffield 5 - 16 project, formed the basis for many other classroom schemes. These varied in emphasis in terms of topic structure, but generally maintained the practical, experimental components. All the initiatives culminated in the introduction of the National Curriculum in 1988. The specific guidelines of the National Curriculum, which govern subject matter and the amount of time per week spent studying science, may have gone some way towards changing perceptions of science and scientists. This may be particularly observable among younger children, who have known no other curriculum approach .

Much research work has been carried out with older secondary school students, as this was perceived to be where the problems of disinterest in science were founded. In fact younger children hold firm views and these will be carried forward into their secondary schooling. If they hold particular views about science, this will colour their impressions of and attitudes towards the subject, before and during their studies at secondary school.

This study aims to find out more about primary children's perceptions of science and scientists, to investigate the extent to which boys and girls hold stereotypical images of the scientist and science and to investigate factors that may be affecting the children's perceptions.

It is possible that the views held by the older, secondary age children could be determined by the views and experiences of the younger children in their primary years. If this is so the introduction of the

National Curriculum should be redressing the balance, in that all primary children are now exposed to rigorous and well defined science study guidelines.

The sample of children involved in the study was determined by their accessibility. Initially, Years 5 and 6 (9-11 year olds) seemed ideal, because they had been in school for a number of years and were well settled in the 'academic' atmosphere. They had, by this age, had experience of a variety of school subjects, including science. They had not had to make decisions about subject choices for GCSE studies, which in turn determine or are determined by their future career choice. In the event, the period of the study coincided with the Statutory Assessment Tasks (SATs) for the Year 6 age group of children and so they were not available as subjects. Therefore the study sample consisted of Year 5 children aged 9 - 10 years old.

State and independent schools were visited for the study. These different types of school serve a differing clientele, who in turn have differing perspectives about the role of the school and what children should gain by being at school. A comparison of similar age children in differing sectors of education would throw light on possible differences in the way children in each sector perceive science and scientists (Dale 1974, Omerod 1981). There was also the opportunity to compare the perceptions of children in single sex and mixed schools. It is possible that the influence of the "public image" of science and scientists, will affect the perceptions of girls in mixed classes differently from those in a single sex group, where there would be no explicit gender pressure in science. Hence mixed classes from both state and independent sectors were included.

The 'Draw A Scientist' test (Chambers 1983) has been used in several studies to determine the extent to which the public image of the scientist is held by children. Though not a perfect tool, its ease of administration and the information it elicits from the children were thought to be valid for its use in this study.

There are a number of factors which could be influential in the formation of children's perceptions, for example, socio-economic and ethnic backgrounds (Schibeci and Sorenson 1983, Kelly 1981). Other factors which might be influential in the formation of children's perceptions, such as parental occupation (Smail and Kelly 1984), television and reading preferences (Bassalla 1976, Schibeci 1986, Omerod et al 1989) and hobbies, (Johnson 1987) were included in the instrument design.

The gender of the science teacher may also have some influence on the children's ideas of who a scientist should be (Omerod 1981, Kelly 1981). Girls taught by men, may use this as a model for their scientist image and conversely boys taught by women. Girls taught by women may have differing ideas about science from girls taught by men. The gender of the children's teachers was noted.

A simple response questionnaire was used to elicit the children's views about science as a subject to study, and science generally. This was adapted from a questionnaire designed for older children by Skurnik and Jeffs (1971), to make it more accessible for a wide range of abilities of primary aged children.

One aspect of science that all younger children seem to enjoy is practical investigation, the 'hands-on', 'finding out' experiments (Woolnough and Allsop 1985, Ramsden 1992, Ebenezer and Zoller 1993). The children holding gender sensitive views about science, could well carry these beliefs through into the practical aspects of science and therefore some girls may feel that some practical work is too difficult because it was the type of activity that boys are more likely to enjoy (Kelly 1983, Johnson 1987, Morgan 1989). Conversely, boys may feel that some activities are not scientific and perhaps more suited to girls. Therefore the children were asked to perform three short science activities and evaluate their feelings about them. It would be particularly unfortunate if girls were to hold negative views about science, as they would be unlikely to opt for a career in the sciences. Conversely, if boys and men held similar views, there would be a likelihood that they would view science as a male preserve and consciously or unconsciously seek to exclude women (Weinreich-Haste 1981, Walkerdene 1989).

The results were collated and analysed using the SPSS statistical package, initially to look for any systematic similarities or differences between the groups of children.

It would be very satisfying to find that the long and widely held view of the scientist could be relegated to the realms of folklore, sure in the knowledge that boys and girls from all types of schools and backgrounds, feel equally able to study science and to pursue a career in science. It is important that both boys and girls have equal access to the fund of scientific knowledge available in order to more fully understand and appreciate the global society in which they live. If only half the population have access to that fund of knowledge, the other half is seriously disadvantaged and to a certain extent powerless to make decisions or to contribute fully to decision making in matters involving scientific criteria. They are also dependent, to a certain extent, on those in possession of the relevant knowledge. This process becomes circular and self-fulfilling (Walkerdene 1989). Men are perceived as having scientific expertise and as being good at understanding how things work; women have been recorded as not seeing themselves as having these abilities and therefore deferring to men, because they understand the principles involved, because they find science easier ...... and so on.

Teachers should be aiming to give an equal opportunity to all children in all subjects. If girls do find some areas difficult then teachers should be searching for ways of making the subjects accessible and more appealing to the girls without prejudicing the boys. It could be that there are fundamental differences that have little initial connection with education that need to be addressed before all subjects can be equally accessed by all participants.

The literature review discusses investigations by others into children's perception of science and scientists. Studies conducted with primary aged children will be considered initially. Similar studies with secondary aged children will be considered in the light of the continuance of the primary children's ideas. Studies relating to both primary and secondary children's ideas about science will be reviewed.

The introduction of the National Curriculum, may well be influential in changing attitudes to science, particularly of younger children. Those who are now ten years old (i.e. Year 5) have had all their scientific experience since the National curriculum was introduced. Science is designated as one of the 'core' subjects of study. As such, the area of study and the amount of time children spend studying science is pre-determined. This is in sharp contrast to primary science before the National Curriculum, which was often dependant on the teacher's willingness to branch out from Nature Study type of science, to broader scientific topics. The teaching of any form of science was certainly not consistent throughout the country (Cox and Taylor 1989).

The new emphasis on large amounts of 'real' science, to which children are now exposed, may well have contributed to a change in attitude to science and the perception of scientists. Many of the studies cited in this study were conducted pre-National Curriculum and any changes in the perception of science and scientists observed in this study will serve as a comparison.

Therefore the questions posed for this study are:

What are primary childrens' perceptions of scientists?

What are primary childrens' perceptions of science?

What are primary childrens' perceptions of science activities?

Are these perceptions the same for boys and girls?

Is there any difference in the childrens' perceptions in different types of school?

Chapter 2

Review of the Literature

In order to answer the questions posed for this study, a review of the literature was undertaken to address a number of areas that were thought to be pertinent and consider other studies in similar fields. The historical background to the provision of science in schools and the relationship of school science to the perception of science by students and the general public were thought to be important in providing a framework from which to investigate current perceptions.

i) Science in Schools

Over a century ago science was the domain of the affluent gentleman and the university academic. One would dabble in scientific experiments as a hobby, the other researched his hypotheses behind closed doors, and subsequently disseminated his findings to small audiences of other interested academics. The public masses, with no knowledge of scientific principles, found scientific discoveries intimidating to some degree, and therefore, difficult to understand and frightening to contemplate. Electricity provides a good example of this phenomenon.The inventions of Swan and Eddison, in the late 1870's, of the electric light bulb, brought electricity into the domestic arena. Michael Faraday's work with electromagnetism enabled electricity to be produced on an increasingly large scale for domestic use. Many people were suspicious of this new source of energy, which they couldn't see, hear, smell or handle and therefore felt they could not control. These suspicions and fears remained for a long time. It is said people straightened out wires in the belief that it helped the electricity flow better. James Thurber's grandmother thought that;

> *"the electricity was leaking out of sockets if the wall switch had been left on........ and dripped invisibly all through the house"*
>
> James Thurber. My Life and Hard Times
>
> (Harlen 1985 p65)

These fears of new phenomena, fuelled by the suspicions about the nature of scientific activities and the people who pursued them, have contributed to the formation of a public image of science and scientists. This has probably been the case since the very early scientists, such as Aristotle and Galileo, first set out to satisfy their curiosity about phenomena they had observed in their surroundings and began challenging religious and secular laws with their findings.

In the latter part of the 18th century concern about the public lack of scientific understanding prompted an initiative from the Royal Institute in London to make moves to inform the public about scientific innovations. The Institute was founded in 1799, with the express intention of popularising science. Sir Humphrey Davy was the first lecturer and Michael Faraday, attending with tickets donated to him, was inspired by Davy's lectures and the Institute's attempts to popularise science. Eventually he also worked and lectured at the Institute and in 1827 inaugurated a series of Christmas lectures for children, thereby bringing science to an even wider audience. These Christmas lectures for children still continue today and as they are televised the potential audience is vast. The audiences attending Faraday's lectures would have been limited to those who could afford tickets, so science was still, despite the Royal Institute's best intentions, the property of the privileged (Woolnough and Russell 1985).

At this time there were changes afoot in the field of education. Reverend Charles Mayo, in 1830 introduced 'common object' lessons into the school curriculum. These lessons were the first attempts to bring science into the classroom and extend learning beyond the realms of the three R's. As the majority of schools were run under the aegis of the church, the science taught was more religious than secular (Cox and Taylor 1983). In 1840 Reverend Richard Dawes made another move to introduce the physical sciences into the school curriculum. Again this was a short lived experiment.

These were isolated initiatives and almost destined to failure as science was not seen as a relevant part of education for children generally and primary age children in particular. As 70% of schools in Britain at this time were under the control of the church, the church controlled the curriculum. Controversial discoveries and theories such as those of Charles Darwin (1859), suggesting that man had descended from the apes and was not created by a God, which he published in the 'Origin of Species', incensed the Church and further ensured that science was unlikely to become a part of the primary school curriculum as the theories flew in the face of religious teachings of the time.

Teaching in elementary schools at this time placed the emphasis on mechanical, rote learning. There was a strong political desire to limit the educational access of the lower classes in the belief that too much education would be detrimental to the poorer people. It was thought much better that they received an education which explained to them the political and economic necessity of their humble station in life. The Revised Code, introduced by Robert Lowe in 1867, put forward a case for educating the poorer people with the almost hidden proviso that they were receiving education in order to better accomplish their roles as subordinates (Wardle 1977). At this time elementary education was paid for at the rate of a few pence per week. Education became free and compulsory following the 'Forster' Education Act of 1870 due largely to reforms in the factories during the Industrial Revolution, which began to improve the working condition of children, thus releasing them for attendance at school. The 1870 Education Act provided a framework for a national system of education, overseen by local school boards. The curriculum was expanded to include woodwork and metal work, called manual work, and practical cookery lessons. Science lessons were taught by demonstration. Further measures in 1876 and 1880 made elementary education compulsory.

By 1918 the government was considering the effect of education on society again, with the result that the Education Bill of that year recommended that the scope of the curriculum should be extended so that the populous could make informed judgements. This process was to start with primary children. The rise of dictatorships between the wars was seen as a result of mass media influence on an unquestioning population. It was decided that an educated society would be less susceptible to propaganda and the curriculum of schools was broadened by the introduction of new subjects such as languages, geography and history. The processes of teaching and learning were to be examined more closely, though this was not to have any significant effect in the classroom until the mid 1920's.

Study of teaching and learning processes had its foundation in the theories of the philosopher John Locke, which were popular towards the end of the seventeenth century. John Locke had influenced teaching of children with his *'tabula rasa'* theories, literally the 'clean slate' of the child's mind on to which teachers would write. The expansion of the curriculum, albeit in a small way, shifted the focus from passive absorption of facts via rote learning, to a more child centred view of education. This led to the beginning of a decline in authoritarian teaching methods and the view that education should start from the child's interests. There had been similar moves, by Mayo (1830) and Dawes (1840), when they attempted to introduce science lessons into the elementary curriculum at the beginning of the 19th century, but this was halted to a large extent by the introduction of the Revised Code in 1867.

Moves to include science in the Primary School curriculum began again in 1905. The Handbook of Suggestions for Elementary Teachers of 1905 included a section on Natural Sciences. Physical Sciences were thought only suitable for older children. Studying nature and a limited amount of biological sciences was deemed appropriate for younger children. This emphasis on Nature Study for younger children was to remain for the next sixty years (Cox and Taylor 1989). It was further reinforced in 1937 by the major reorganisation of the educational system. The Education Act of 1937 suggested that there should be separate schools for the education of the post-primary age group. This group was deemed as starting at 11 years old. This separation of the age groups into separate schools ensured that the split between nature study and the physical sciences was institutionalised.

Studies of that time, in the field of children's learning, began to indicate that children learned more effectively if they had practical experiences and if these experiences were provided in a continuous series so that they could be built on as the children developed cognitively (Piaget 1930). Up to this point, science had not really been regarded as a vital component of the primary curriculum in the Handbook of Suggestions. The Ministry of Education, encouraged primary school teachers to consider science at primary level, in the light of these findings, but no real changes had occurred. The decline in John Locke's *'tabula rasa'* theory and the increased emphasis on child centred learning continued to influence some areas of teaching, but did not really take hold until the publication of the Plowden Report in 1967 (CACE 1967). The Report contained suggestions for increased practical science activities for primary children. This led to the formation of the Nuffield 5-13 project, which placed emphasis firmly on practical work and discovery learning, with topics thought to be of interest to children. Physical sciences began to appear in practical projects, as part of the scheme and the balance of physical and natural sciences began to equalise, though still not to any large extent in the primary sector, where Nature Study still tended to predominate.

The Prime minister at that time, Harold Wilson, realised the importance of science and scientists in the economic and social growth of the British nation and his ideas helped to reinforce the need for teaching science in schools (Harlen 1992). Continuing change and development in society's needs and expectations and consequent moves towards a more technologically based economy have required, over the years, that increasing numbers of young people move into careers in science and engineering to maintain and expand the workforce required to compete in the global arena. The moves instigated by Harold Wilson to increase science and technology education were taken up by the subsequent Prime Minister James Callaghan (1976) and there followed The Great Debate of 1977. This was instigated by the then Secretary of State, Shirley Williams, and highlighted the differences in experiences of children in primary schools across the country and called for a revision of the primary school curriculum. Science in primary schools was highlighted as being particularly diverse in its approach, ranging from lessons which led to observation and experimentation to those which were totally information gleaning from books. A need to ensure equality of experience for primary children across the country and ease their passage into secondary education was identified (Thomas 1990). Though part of the 'Great Debate' concentrated on the needs of primary education, the needs of the whole statutory age range of 5 - 16 years were addressed. There have followed many projects and schemes designed to raise the awareness of pupils and teachers of the importance of science, particularly at the primary level, culminating in the introduction of the National Curriculum in the 1988 Education Reform Act.

With its raised profile and the tremendous economic and man-power investment, it would be reasonable to expect that the uptake of science as a career might be on the increase. However, scrutiny of the examination statistics reveals that the popularity of the sciences, particularly physics, as GCSE (formerly 'O') and 'A' level choices is on the decline (DFE 19 85 - 93). Also, despite equal opportunity initiatives, girls are still not choosing science for the 'A' level examination in the same number as boys, neither are they opting for a career in science or the related area of engineering, in any significant numbers. There are a number of possible reasons for this, one of which may be children's and student's perception of science and scientists.

The disparity in the numbers of male and female students choosing to study physical and biological sciences, though moving slightly, has remained imbalanced for many years. This imbalance causes concern in that there seem to be factors in operation which are discouraging women from entering careers in physical sciences and the related engineering areas. This, in combination with a general decline in students entering higher studies in scientific subjects, opting instead for art and language based subjects, highlights the governmental concerns of maintaining the workforce and providing opportunities for equal access in all areas.

If students and older children have a particular concept of science as a subject and scientists as people, they must have formed these ideas through their earlier experiences. It is worth considering where, when and how these concepts are formed. By examining the literature on children's ideas of science and scientists, it may be possible to ascertain if the public stereotype of the scientist still exists and if it is held by younger children. Children influenced by stereotypical views of scientists may continue to hold this view throughout their school experience until additional experiences convince them otherwise.

ii) Primary Children's Images of Scientists

Much of the research to date in respect of images of scientists has been concerned with older children (Kelly 1987, Omerod 1988, Morgan 1989, Tuckey 1992). Increasingly there is an awareness of the relevance of younger children's ideas and their impact on attitudes to their later years of schooling (Dale 1975, Smail and Kelly 1984, Osborne and Wittrock 1985).

Exploring children's images of scientists can be a useful tool in investigating their attitudes to science. One of the major problems of eliciting information from younger children is their relative lack in communication skills, in comparison with older, secondary age children. Thus the more traditional paper and pencil type of tests such as the Science Attitude Scale (Shrigley 1984) and the Images of Science and Scientists Scale (Krajkovich and Smith 1982) are relatively difficult to use with younger children, due to the levels of reading and comprehension skills required. The method used by Mead and Metraux (1957) in their seminal study of attitudes to science, which consisted of completing unfinished sentences in the form of a short essay, would be far beyond all but the oldest and most able primary age children, again because of the level of literacy skills involved.

In order to investigate younger children's ideas other methods have had to be developed. Chambers(1983) devised a drawing test, partly influenced by and based on the Goodenough Draw-A-Man test (1926) which had been used previously to assess young children's intelligence. The Goodenough test, devised in 1926 by Goodenough and revised by Harris in 1963, requires the child to draw a picture of a person. The number of indicators present in the form of eyebrows, nose, fingers and the style of the depiction of limbs is then calculated to give an accepted measure of the child's intelligence. This test is and has been used quite extensively in the psychological and educational assessment of children. Chambers' (1983) test requires the children to draw a scientist, and thus can be used with all ages and abilities of primary age children as it requires no reading or writing competence. Primary children are usually willing and eager to execute drawings

The original stimulus for the development of the Chambers test, which he called the Draw-A-Scientist-Test (DAST) was the Mead and Metraux study of 1957. Analysis of the responses in this study, resulted in a distilled image of the scientist, which has come to represent the stereotypical or, as Chambers(1983) describes it, the 'standard' image of the scientist. This distilled, standard image of the scientist as apparent from the Mead and Metraux (1957) study showed the scientist to be an elderly, white man, balding with glasses and wearing a laboratory coat and working with scientific equipment. Chambers(1983) used these features as a base to form a scoring method for his DAST and thus his scale of seven indicators was formulated. The scoring system is represented in Table 1.

Table 1. DAST indicators from Chambers (1983) p 258

Indicator	
laboratory coat	1
eyeglasses	1
facial growth of hair	1
symbols of research	1
symbols of knowledge	1
technology	1
relevant captions	1
Total	7

For each indicator present a score of 1 is given. If there are two indicators present at the same level, for example, test tubes and a Bunsen burner, then only one of these is scored, as indicator 4 in this case. A drawing with all seven indicators present, Chambers suggested, represented the 'standard' image.

Chambers' 'standard' image of seven 'indicators' identified from the Mead and Metraux study, thus represents those elements in children's drawings which

> *'portray directly some part of the scientist's actual world' or 'may be taken as symbolic of some part of that world'*
>
> Schibeci and Sorensen (1983) p 16

Chambers' original study took place over a period of eleven years from 1966 - 1977 and consisted of a sample of 4,807 primary age children, in 187 classes, from schools in Canada, America and Australia. The children were kindergarten to Grade 5 (approximately 5 - 11 years old) with the largest number of participants at the Grade 2-3 level (i.e. age 7 - 9 years old). This vast sample of children's drawings was analysed using the seven indicator scoring system; thus each child was given a DAST score. These scores were compared with each other for items such as age, socio-economic group and ethnic background. A separate analysis was used to gain a picture of the gender of the scientists. The gender of the scientist was not included in the seven indicators to be scored for the test. Out of this vast sample of children's drawings from 3 different countries and a variety of socio-economic and ethnic backgrounds, Chambers found that only 28 children (approximately 0.6%) drew pictures of female scientists. All these pictures were drawn by girls and no boys drew female scientists. This was an important result from the DAST which will be discussed later.

The number of 'indicators' represented in the children's drawings was found to increase with age, so that by Grade 5 level (age 10), 4-5 indicators on average were included on each drawing, with a few that contained 6 or 7 indicators. Adults, including some scientists, who were given the DAST obtained scores of 4 to 5 indicators (Chambers 1983). This indicated that some aspect of the stereotypical scientist was held by those tested.

Chambers (1983) does not elaborate on the actual indicators recorded. Chambers(1983) suggests that this level of number of indicators is indicative of a standard image being held. The fact that few subjects attain the full DAST score of 7 seems to indicate that there is a problem with the allocation of indicators. Chambers (1983) suggests that indicators such as symbols of knowledge, are represented by the presence of books, symbols of technology and the presence of the products of science, and relevant captions are represented by the depiction of formulae and words such as "eureka". It may be that in drawing a scientist these factors are the last to be considered. This consequently lowers the potential score of subjects. This may explain why a full DAST score of 7 is rarely achieved. This is possibly a fundamental drawback to this test.

Chambers' (1983) study was carried out in three countries, Australia, Canada and the United States of America. There appeared to be no differences between the children's scores in the three countries, that is the DAST scores seemed to be consistent in each country, in terms of the emergence of the standard image and an increase of score with age. But differences were seen in all 3 countries that were attributable to socio-economic groups (Chambers 1983). Indicators seemed to be slower to emerge in the children in the lower socio-economic groups in all the countries. This is explained as being due to the children from lower socio-economic groups being less aware of the popular attributes of the scientist.

A DAST is easily and quickly administered and this, together with no requirement for reading, writing or comprehension skills, is seen by many as an advantage, particularly with younger children. The test consists of the instruction "Draw me your best picture of a scientist". Children are given a blank piece of paper and are expected to follow the instruction without any preamble or prompting.

This test has become a commonly used instrument for determining young children's images of scientists. Concerns have been expressed as to the image the children are drawing, whether it is their own image or the image that they feel the adult requesting the drawing would like to see (Symington and Spurling 1990). Nevertheless comparisons of the various studies that have used the DAST test could be viewed as legitimate in that every administration of the DAST will suffer from the same problems and inadequacies.

Many of the studies have concentrated on the gender of the scientists and have not produced the DAST scores for the children involved, so the various studies can be compared on two levels, that of the gender of the scientist drawn, and the DAST scores, where available, which indicate the extent to which the children represent in their drawings the 'standard' image of the scientist.

Looking firstly at the group of studies which have concentrated on the gender of the drawing of the scientists, all seem to report the same findings, that is that the majority of the drawings of scientists depict a male and those that do depict a female are usually drawn by girls (Chambers 1983, Symington and Spurling 1990, Tuckey 1992). Newton and Newton (1991) looked at over a thousand children's drawings in the Reception to Year 5 age range (5 - 10 years old). No statistical analysis seems to have been carried out on the results but the authors state that

> *"the scientist tends to be seen by boys and girls alike as a balding, bearded man who wears a white coat and spectacles."*
>
> Newton and Newton (1991) p20

The above statement implies that the children's drawings include many of the indicators that Chambers(1983) identified as indicating the standard image of the scientist though no statistical or numerical analysis is available for the exact numbers.

Other studies using the DAST have revealed that there appears to be a stereotypical image of the scientist as male, represented by young children from the beginning of their schooling as found by Newton and Newton (1991). A group of Year 3 (7 year olds) with approximately equal gender ratio produced no drawings of a female scientist (Pickford 1992). Another group of Year 3 children, 11 boys and 5 girls drew only male scientists (Preston 1995). In both these studies the DAST score is not recorded but the presence of indicators such as laboratory coats, spectacles, equipment, facial hair and laboratory settings is referred to, implying that the stereotypical image is present in some form. Studies by both Chambers (1983) and Schibeci and Sorensen (1983) suggested that the stereotypical image of the scientist emerges at about age 6 years. It is reasonable to assume that these Year 3 children, aged 7, conform to this finding. Also it would be expected that the stereotypical image of the scientist would continue to be present in older children. A group of 30 Year 4 children (8 year olds) drew 25 representations of a male scientist and 4 representations of a female scientist. Unfortunately there is no indication of whether these were drawn by girls or boys. However, the children, when revisited a year later, all drew male scientists (Jannikos 1995). A mixed group of Year 4/5 children (8-10 year olds) produced five pictures of female scientists out of a total of 32 drawings. All these were drawn by girls (Pickford 1992). A group of 29 Year 5 and Year 6 children (9-11 year olds), when asked to draw a scientist, produced 27 representations of a male scientist and 2 representations of a female scientist, drawn by one boy and one girl (Hobden 1993). A further group of Year 6 children (11 year olds) of roughly equal gender proportions, produced no drawings of female scientists from 30 drawings (Pickford 1992).

This group of studies seems to indicate that when exposed to the instructions 'Draw me your best picture of a scientist', most children, irrespective of their own gender, will draw a picture of a male figure. The numbers of drawings of each gender has been collated from all the above studies and is represented in Table 2.

This gender typing appears to be little changed from 1957 to the present. Those children who do draw a female scientist are most likely to be girls, though this is not noted in every study using the DAST. These studies have been carried out, as far as is ascertainable, using the Chambers DAST (1983) in the same format as the original study. This scoring format does not include the gender of the scientist in the drawing.

Table 2 . Gender drawings from selected studies based on the Draw a Scientist Test.

Age of children	Gender of Scientist			
	male		female	
	No.	%	No.	%
7 years (Y3) (Pickford 1992, Preston 1995) N = 32	27	84.4	5	1.5
8 -9 years (Y4/5) (Jannikos 1995, Pickford 1992) N = 30	25	83	4	1.3
9 - 10 years (Y5/6) (Hobden 1992) N = 29	27	93	2	0.6
10 years (Y6) (Pickford 1992) N = 30	30	100	0	0

Other studies have adapted the DAST format in the light of some of the criticisms levelled at its validity and the nature of results obtained from the scoring system. The instructions for the DAST have been said to be misleading. The request to "Draw a picture of a scientist" is said to be interpreted by the children as "Draw me a picture that will show me that you know who a scientist is". This is said to be requesting the stereotypical image. If this is the case then there is a stereotypical image of a scientist and the children are aware of this if they produce a drawing of a man in response to the original request. The fact that the instructions have been altered to "Draw me a picture of a man or a woman scientist" (O'Maoldomnhaigh and Ni Mhaolin 1990) and that this instruction produced more pictures of a female scientist does not necessarily mean that the children consider men and women equally likely to be scientists. It may indicate that they have exercised a preference. Requesting a second drawing from children which tends to produce slightly more pictures of female scientists (O'Maoldomnhaigh and Hunt 1990) does not necessarily indicate that the children, particularly girls, regard the scientist as female and feel free to produce this drawing once they have produced the male stereotype. It could be that they have drawn a man and therefore now they will draw a woman, for variety. Even so if they do feel that they are unable to express a female representation of a scientist until they have represented a male scientist, as is claimed by O'Maoldomnhaigh and Ni Mhaolin (1990), this again suggests that there is a stereotypical image of the scientist as male and the children, particularly the girls, are aware of this.

The scoring system of the DAST gives only an indication as to how close to the stereotypical image of the scientist, the children's pictures approach. It has been found that the number of indicators increases with age with the largest number of indicators being present by the age of 9/10 years old (Chambers 1983, Scibeci and Sorensen 1983). This number does not increase significantly in pictures drawn by adults. If the picture drawn by a child has only 1 or 2 indicators of the standard image, how true is it to say that the child holds a standard image of the scientist? The fact that these 1 or 2 indicators tend to be a laboratory coat, spectacles and/or balding head (on a male figure) with the presence of one or more of these three features in a drawing, could lead the investigator to assume that the standard image is held by the child. It is often the case that the DAST scores are not recorded for the study, but it is stated that the children hold the standard image. This may be an assumption on the part of the investigator given that what could be called the 'major' representations of the stereotypical scientist are there, i.e. the laboratory coat, balding head and glasses. A low score of 1 or 2 indicators should indicate that the stereotypical image of the scientist is only tenuously held.

It is possible that the images represented by the children in their drawings are not necessarily the image they hold but that the drawings they produce are those which the children perceive to be the public stereotype of the scientist or required by the person requesting the drawing (Symington and Spurling 1990). This suggestion is based on the study by O'Maoldomhnaigh and Hunt (1988) which used an adapted version of the DAST to explore the images represented in the children's drawings. The contention of Symington and Spurling (1990) that the drawings might not be representing that which the researches had hoped for, is further echoed by other studies which have used an adapted form of the DAST (Morgan 1989, O'Maoldomhnaigh and Hunt 1988, O'Maoldomhnaigh and Ni Mhaolain 1990).

One of the major criticisms of the DAST is that the instruction given to the children is eliciting the wrong response or a response that does not actually give a great insight as to reasons behind the image presented. To this end various studies have worked with a modified version of the DAST (Morgan 1989 , Tuckey 1992). The modifications are different for each study as different aspects are investigated. These studies help to throw some light on the various aspects of images concerned in the drawings and other aspects such as the type of instruction and the value of talking to the children about their drawings.

In order to probe more deeply into the reasoning behind the children's drawings Tuckey (1992) asked for the picture to be given a caption to explain what the scientist was doing. This study was conducted in the Stratosphere, a 'hands on' science centre in Aberdeen, Scotland, and used a sample of 135 children who visited the centre. There were 61 girls and 74 boys aged between 8 and 11 years old. Because some of the drawings proved difficult to analyse only 121 could be used. The analysis of the drawings itself produces its own difficulties as the interpretation of children's drawings can be open to subjective judgements in terms of what indistinct elements may represent. One way of overcoming this is to have more than one person to analyse the drawings and seek a degree of agreement between the judges' opinions (Symington and Spurling 1990, Tuckey 1992).

The categories that Tuckey (1992) assigned to the drawings arose from the captions that the children had given to them, the largest proportion of which were put into the 'mad scientist/alchemist' category. Of the 121 drawings Tuckey (1992) found that only girls drew female scientists, thus confirming the findings of Chambers(1983) and Schibeci(1983). What is interesting is that the proportion of girls drawing female scientists was much higher than in any other study. This suggests that there may have been a shift in the perception of the children as to who a scientist may be (Tuckey 1992). A male scientist was drawn by both girls and boys but the boys drew exclusively male scientists. It would appear that boys still held a very stereotypical idea of scientists and that this was often associated with weird and magical aspects of science (Tuckey 1992). The fact that the children were visiting a science exhibition may have had some influence on their interpretation of the scientist. Tuckey (1992) does not account for this in her analysis. The teachers of these children expressed an awareness of the

> *"need to avoid gender stereotyping"*
>
> Tuckey (1992) p31

They believed that this awareness could be influencing their teaching, and thus the children's stereotypical perceptions, thus accounting for the higher proportion of female scientists drawn.

An adapted DAST undertaken by O'Maoldomhnaigh and Hunt(1988) explored the extent to which the 'standard image' of the scientist was held and how this could be influenced by teacher input. The adaptation took the form of exposing three groups of children to lessons about the life and work of two different types of scientist. Darwin and

Eddison were used as examples of an atypical scientist and a typical scientist respectively, and the third group continued their normal science lessons i.e. had no exposure to the life and works of any scientist. At the end of the 6 week session the children were asked to draw a scientist as per the original DAST. On completion of the first drawing they were asked to 'draw another scientist'.

The children in this study were from similar socio-economic (upper middle class) backgrounds in Limerick City Ireland. They were all in the last years of their primary school (mean age ten and a half years). Analysis of the drawings showed that the number of indicators present was generally consistently the same for boys and girls though girls did tend to score at either end of the indicator level. This could be because girls have a potentially lower score if they draw a female scientist as their drawings automatically do not score on the facial hair indicator (O'Maoldomnhaigh and Hunt 1988). The findings showed that no boys drew a female scientist in either their first or second drawings. Of 74 drawings (both first and second drawings) by 37 girls, 23 drawings were of female scientists and the majority of these were produced in their second drawing i.e. their first drawing depicted a male scientist. Again it would seem that the boys held a 'standard' image of the scientist as being male, and though a higher proportion of girls overall, if both drawings are included, drew female scientists than was found by Chambers (1983), this is not directly comparable, as the majority of girls drew the female image in their second drawing. This was despite the fact that two thirds of the girls participating had been exposed to a series of lessons on the life and work of male scientists. O'Maoldomhnaigh and Hunt(1988) suggest that the image that the children hold can be influenced by exposure to the life story of great scientists and suggest a need for an investigation using the life and work of female scientists.

The representation of mythical scientists was found to be mainly the domain of the boys. Girls who did draw a mythical scientist did so only in their second drawing. This was held by Maoldomhnaigh and Hunt(1988) as suggesting that the children, girls in particular , who held an alternative view of a scientist, felt freer to express this once they had represented the 'acceptable' image of the scientist.

A later study by O'Maoldomhnaigh and Ni Mhaolain (1990) investigated the possibility of the instructions influencing the children's choice of a drawing. As the findings of their previous study (O'Maoldomnhaigh and Hunt 1988) had indicated, the children drew what they felt was considered to be the accepted image in the first instance and then when given the opportunity to draw a second image, represented an alternative image in the form of a 'mythical' scientist or a female scientist. In order to investigate the effect of the instructions on the type of drawing produced, O'Maoldomhnaigh and Ni Mhaolain (1990) altered the instructions to "Draw a picture of a man or a woman scientist", for one part of the sample and used the original "Draw a picture of a scientist", instruction, for the rest of the sample. Their sample consisted of 299 girls and 68 boys ranging in age from 11 years and 9 months to 15 years and 9 months. Subjects were randomly assigned to one or other of the instruction type groups. The children produced one drawing and then two weeks later were asked to produce a second drawing. This differs from the O'Maoldomhnaigh and Hunt (1988) study in that there was a time lapse between the two drawings. The original study had asked for consecutive drawings. They found a higher proportion of female scientists were produced when the instruction "Draw a man or a woman scientist" was used. The drawings produced by boys with either set of instructions still showed a high representation of the scientist as male. There were also differences in the age of the children, in that the first study used primary age children and in the second the children were older. This may account for some of the differences. If the instruction 'Draw a man or a woman scientist' was used with younger children, it is unknown what different representations of the scientist may be expected.

One of the problems encountered in the DAST studies is that of the child who cannot start. In both the O'Maoldomhnaigh studies (1988 and 1990) they encountered this and encouraged a start by suggesting to the child "Do as you think best" and allowing the teachers to give practical advice. Schibeci (1986) also encountered the reluctant artist and used the suggestion "Draw a picture of a man". This is not necessarily the best instruction to give to children who are reluctant to draw anything when the gender of the scientist drawn is being sought. The possibility of this instruction itself and the possibility of it being overheard by other subjects may influence the type of drawing they produce, thereby creating an unwanted bias. Harlen (1992) suggested that this reluctance to start drawing was because the children in fact had no image of the scientist and that this applied to all the children taking part and so the drawing they produced was in fact that which they felt the instructor wanted to see. Wynne Harlen (1992) states,

> " *young children do not have enough experience of scientific activity and its consequences to form opinions and attitudes towards science. If they seem to hold such attitudes it is as a result of accepting adult prejudices and parroting views which are not their own*"
>
> p 39

If this is so, then it calls into question the results of all the above studies. It is more likely that the image the children hold is a distillation of personal experience and a notion of ideas gleaned from adults. It would appear that the image of the scientist held by primary children is that of the stereotypical image, the older man in the white coat. The gender of the scientist appears to be closely linked to this stereotypical image, though the studies so far seem to cloud the issues of gender and stereotypical image, possibly because the two are inextricably linked to other factors affecting the formation of younger children's image of the scientist. If there is a move towards reforming the view of the scientist as being female, it appears to be made, in a small way by the girls.

The appearance of the 'mad scientist' in children's drawings does not seem to be frequent, except for the study by Tuckey (1992). 'Mad scientists' were seen in the original DAST (Chambers 1983) and were termed 'alternative images'. The appearance of the 'alternative image' was noted to appear at around the same time as the standard image of the scientist. Bassalla (1976) had first noted the 'alternative image' in relation to television and media representation of scientists. This will be discussed in more detail later. In all 4.9% of Chambers subjects produced an 'alternative image' but it is not noted whether these were drawn by boys or girls. The 'mad scientist' was noted to appear in the second drawings of both girls and boys when asked to produce two consecutive drawings. This was thought to be an expression of the child's real perception, once the activity had been completed in line with that thought to be required by the teacher (O'Maoldomhnaigh and Hunt 1988). It is more in line with the mythical, magical scientists portrayed in science fiction novels and on the television and may result from these sources. It seems to be the domain of boys, though not all studies record the gender of the artists producing 'mad scientist' drawings. Because one of the criteria of the standard image is a dishevelled appearance, there must be some difficulty in interpreting the children's drawings and assigning them to an 'alternative' category. Thus the category 'alternative' or 'mad scientist' must be open to debate.

iii) Secondary Student's Perception of Scientists.

The image of the scientist that primary children hold will be carried through into their secondary education. Depending on their subsequent experiences, this image will be altered or reinforced.

In 1957 Mead and Metraux revealed the image of the scientist as held by American High school students. This enormous and detailed study, involved analysing 35,000 short essays written in response to a series of unfinished statements about scientists. The image that was revealed was that of

> *"....a man who wears a white coat and works*
> *in a laboratory. He is elderly or middle aged*
> *and wears glasses. He is small, sometimes small*
> *and stout, or tall and thin. He may be bald.*
> *He may wear a beard, may be unshaven and*
> *unkempt. He may be stooped and tired.*
> *He is surrounded by equipment:....."*

Mead and Metraux (1957) p 387

They also revealed that there was a positive and a negative image for the scientist. The positive image was that of a dedicated, very intelligent man, working selflessly for the benefit of mankind. The negative image in contrast was of a selfish and boring man, plodding through his complex experiments alone in his laboratory. In both instances, the positive and negative, the nature of the scientists' work was seen as tending to isolate them from normal society. This aspect, of the scientist's personal and social attributes, may be a significant underlying factor in the formation of the stereotypical image. More recently the type of work a scientist undertakes is seen as being part of the stereotype. The 'abnormality' of the image of the scientist, discernible in both the negative and positive images identified by Mead and Metraux, can be seen in the way the activities and jobs of scientists are classified. Research scientists, physicists in particular, are described as the most intelligent, most socially isolated and least normal of scientists. Biologists have been described as close to the normal average American male. Engineers are seen as most normal but not particularly intelligent and lacking in social graces (Weinreich-Haste 1981). These perceptions of unfavourable and anti-social characteristics of scientists appear to prevail amongst older students in the United Kingdom, Australia and America (Schibeci 1986). These attitudes are seen as likely to colour the student's attitude to science itself.

Methods to assess secondary students' image of the scientist are invariably linked with enquiries into their attitude to science. The Draw A Scientist Test (DAST) (Chambers 1983) has not been used extensively with older students, though Mead and Metraux asked some of the participants of their study to draw a scientist, as part of their assessment of visual materials related to the image of scientists. This was part of a smaller sample of subjects and the results are not recorded separately from the main study.

The factors that make the DAST a useful tool for younger children are not as relevant for the older children, where more complex methods of enquiry can be used. Those instances where the DAST has been used, tend to be an extension of an enquiry into the images of scientists held by younger children (Schibeci and Sorensen 1983, O'Maoldomnhaigh and Ni Mhaolin 1990). Of those instances where the DAST has been used with older children the results are consistent across various western cultures and concur with the findings of Chambers (1983) and Schibeci (1986) reported from younger children, namely that of the image of the scientist as being male, wearing a laboratory coat and working in a laboratory with his equipment (Boylan et al 1992). Schibeci and Sorensen (1983) used the DAST with the express purpose of examining the test's potential as a method of assessing students' images of scientists. The study looked at the drawings made by groups of children aged 6 - 13 years. They found that more indicators of the stereotypical image were present in the older children. Moreover, the increased number of indicators per drawing suggests that the older students have a more strongly held image of the stereotype than the younger children. The use of the DAST offers a dichotomy of interpretations. The indicators used in the analysis of the drawings, do not take account of the gender of the scientist represented, that is other than to decrease the score of drawings of female scientists, due to the facial hair element. Thus the gender of the drawing, taken in isolation from other indicators used for scoring, is one line of analysis. The extent to which the stereotypical image is held and its emergence with age offers a second. This dual use of the DAST, the analysis of gender and 'standard' representation of scientists, is suggested by the results from Chambers' (1983) original study, when he noted that, in addition to the DAST scores for each drawing, only girls drew women scientists.

One advantage of more in depth methods of enquiry is that a fuller picture of the students' perceptions can be gleaned. Inevitably the request to draw a picture of a scientist results in a single image from that instant in time. This may not be the full picture (O'Maoldomnhaigh and Ni Mhaolin 1990, Symington and Spurling 1990, Boylan et al 1992).

A partial repetition of the Mead and Metraux (1957) study was undertaken to ascertain any changes in perception of the scientists. Completion of a series of unfinished sentences in the form of a short essay and the resultant analysis showed that the image of the scientist had remained effectively unchanged since 1957. The study used a group of equal numbers of boys and girls aged 13 and 14 years old from two single sex comprehensive schools. The students were asked to complete five sentences:

" *When I think of a scientist I think of.................*

I would like to be a scientist because.................

I would not like to be a scientist because...........

I would like to marry a scientist because...........

I would not like to marry a scientist because".......

Weinreich-Haste in Kelly (1981) p 224

The responses to the first question revealed a stereotypical image of the scientist, which Weinreich-Haste (1981) stated was virtually unchanged in the twenty years since the original study. The descriptions of the physical appearance of the scientist revealed many of the features present in the Mead and Metraux (1957) study. Namely

" a man in a white coat with a bald head and glasses,

writing on a clipboard standing in front of a bench

covered with apparatus"

Weinreich-Haste in Kelly (1981) p224

That the scientist was male was specifically referred to in one third of all the responses. That a scientist might be physically unattractive and not socially conforming was commented on 'extensively' by the students. Further, other aspects of the stereotypical image of the scientist as highly intelligent, insular, hard-working and doggedly committed to the pursuit of scientific discoveries, came from the students' responses to the other questions particularly those about marriage to a scientist.

> *"They seem too wrapped up in their work, only seem to be bothered with their experiments. A scientist really has to be 'married' to his job. I'd get sick of his persistent braininess and his solitude. She might be cleverer than me and show me up."*
>
> Weinreich-Haste in Kelly (1981) p226

There was a slight difference in the attitudes portrayed in the responses to the questions about becoming a scientist when the students presented a 'broader and more positive image' of the scientist, when considering reasons they themselves would like to be scientists. These involved altruistic sentiments and the possibility of discovering something 'no-one had thought of before'. But the stereotypical image was again revealed, in an exaggerated form, when the students considered reasons for not wishing to be a scientist. The responses included aspects such as boredom, with the job and subject, the difficulty, complexity and dangers of science and the superior intellect that was required of the scientist.

> *"Science is very unfeeling......It doesn't make any*

difference whether you understand Newton's laws of gravity - gravity still exists whether you know about it or not. Working day in day out, to come to a conclusion which never seems to materialise."

Weinreich-Haste in Kelly (1981) p225

Thus the image of the scientist held by 13 and 14 year old students revealed by Weinreich-Haste (1981) was that of a cold, unemotional man, and this is little changed over a period years. The duality of images, that of the positive and negative aspects of the scientist in both personal and social terms, was still apparent and appeared to vary according to the nature of the scientist's work (Weinreich-Haste 1981).

Discussion with students revealed a complexity of reasoning behind their representations which the drawing on its own did not allow to be expressed. The use of the Interview about Instances (IAI) procedure, developed by Osbourne and Gilbert (1979) probed deeper into the students' perceptions. When shown illustrations of a variety of people, both men and women, of various ethnic origins, covering numerous aspects including appearance and workplace, students were quite clear as to which illustrations represented their image of a scientist. They generally selected the bearded male wearing a laboratory coat and glasses. There was no apparent difference in response between male and female students as previously identified (Chambers 1983, Schibeci and Sorensen 1983, O'Maoldomnhaigh and Hunt 1988), nor was there any change in the pattern of responses in relation to Grade level or age. The nature of the work that scientists do appeared to have some impact on the images held by the students. When questioned more closely the students, though stating that the scientist was more likely to be male, elderly and wearing a laboratory coat, actually saw no reason why a woman could not become a scientist (Boylan et al 1992). This is a reflection of the dichotomy of the images held by students., in that though the initial response to who is a scientist may be that he is male the same students in fact have no difficulty in accepting the possibility of female scientists.

There appears to be an increase in the students' understanding of the nature of scientists' work from Grade 3 to Grade 8 amongst Australian and Malay students, though this image is predominantly male and dresses in a laboratory coat. This is seen in Eastern and Western cultures (Boylan et al 1992). Evidence of the representation of scientists as women and younger men without beards has been seen in publicity material in China, though there appear to be no statistics as to students' image of scientists in China (Chambers 1983).

The close relationship between the students' image of scientists and their appreciation of what being a scientist entails is evident. It would appear that students can hold and express the stereotypical image of scientists, whilst being aware that this is not the reality. This is probably a reflection of the reality of the situation as the students see it rather than their perception of the potential for women to be scientists (Boylan et al 1992).

Other methods of enquiry, though not specifically seeking to identify the perceived gender of scientists, have revealed that students actually perceive the scientist as being male, with many of the features identified by Mead and Metraux (1957) and the later studies above. When asked to attribute a number of jobs and professions to either males or females, jobs and professions associated with the sciences and engineering were designated by the students as men's jobs (Kelly, Whyte and Smail 1984). Therefore it is reasonable to assume that the people who do these jobs are male and therefore scientists are mainly male. The personality characteristics associated with the stereotypical scientist by the students, namely being cold, single minded, interested in things not people and avoiding emotional and social relationships are in direct opposition to the characteristics associated with the stereotype of Western women. This reinforces the image of the stereotypical scientist as being male (Weinreich-Haste 1981).

Concern about this stereotypical image of the scientist persisting today, particularly among secondary school students, has been linked to the effect it might have on girls electing to study science courses and enter careers in science and associated disciplines. Whether the stereotypical image of the scientist as being male influences any other decisions is open to debate in the light of the qualifying comments made by students when deeper methods of probing their responses are used.

iv) Primary Children's Image of Science - The importance of early experience

There are relatively few studies which address the area of primary children's attitude to science, as this is a relatively new area of interest highlighted by the implementation of the National Curriculum. Interest in children's attitude to science has mainly centred around secondary school students as a result of governmental and educational concerns with regard to falling numbers enrolling for science courses and examinations. This particular area will be dealt with in more detail in the next section.

It has been seen that children as young as 4 to 5 years of age hold a stereotypical image of a scientist (Chambers 1983, Schibeci and Sorensen 1983). Therefore beliefs about of the nature of the scientists' work and of science itself are likely to be linked to this image. If the predominant image of the scientist is that he is male, children may view science as a male preserve, even at this early age. They therefore may enter school with the idea that a scientist is male and the study of science is something that men do.

It is thought that an interest in science is established earlier than an interest in any other school subject. A review of 32 research items revealed:

> *"in one way or another that abiding interest in science was established at an earlier age than interest in any other area"*
>
> Omerod and Wood 1983 p 77

This 'early age' is thought to be around 7-8 years of age (Smail and Kelly 1981). Areas of scientific interest have been observed to have diverged by the age of 10 years old, girls generally preferring biological based sciences and boys preferring those areas of science with a mechanical or physics bias. This divergence of interest has been observed in younger children working on the topic of electricity (Morgan 1989).

> *"They[ ]come to primary science with existing models about science being something which is mainly a male sphere and hence more appropriate, or easier for boys."*
>
> Morgan 1989 p 37

It could be that the scientific interests of the children diverge much earlier than 8 years old as formally thought. Indeed one study suggested that 5 year old children were actually more scientific in their outlook than older children (Osborne and Wittrock 1985). If younger children view the scientist as male and science as a topic that men and therefore boys study, this question must be linked to the way the children view themselves in terms of their gender. Young children are aware of their gender from an early age, certainly by the time they start to socialise with other children and they also have some idea of the differences between what is expected of men and women in their own culture.

Work on gender stereotyping indicates that very young children are aware of their gender and behave in a 'gender appropriate' manner. This has been observed in very young children, approximately 1 year old, indicating that a degree of gender divergence is well established before entering school (Maccoby and Jacklin 1974).

The studies, reported in Maccoby and Jacklin (1974), indicate that 1 year old children have established preferences for particular toys, said to be gender appropriate. The attributes of the toys that determine the child's choice are as yet unclear. The preferences for 'masculine' or 'feminine' toys continues and is still apparent in the nursery where 4 year old boys have been observed to spend more time playing with blocks and wheeled toys, the girls spend more time in the 'home corner' (Maccoby and Jacklin 1974). Boys at nursery age also appear to be more gender stereotyped than the girls. This is concluded from the avoidance in boys, of gender inappropriate activities, such as 'playing house'. This avoidance of gender inappropriate activities continues throughout childhood and has been observed to be still prominent in male college students (Maccoby and Jacklin 1974).

The selection of activities could be said to be as a result of the children imitating the activities of their parents. Girls see their mothers cooking, cleaning and generally looking after the needs of the family whereas they see their fathers generally mending things around the home. The situation is not as clear cut as pure imitation and there are other factors involved in gender appropriate behaviour. The child's awareness of his gender is reinforced by the cultural and social expectations ascribed to that gender in the society in which the child is being reared (Maccoby and Jacklin 1974, Öhrn 1993).

Parents are also subject to social and cultural expectations. There is a tendency to treat male and female children differently, girls being generally treated more gently than boys, who are encouraged to engage in 'rough and tumble' type games. Parents have been seen to encourage gross motor activities of baby boys, by pulling and tugging at their arms and legs in response to the child's movements. This is thought to encourage the baby's visual spatial awareness, which has been regarded as conducive to success in maths and physics in later life. Maths and physics are said to require a greater degree of visio-spatial awareness to mentally manipulate numbers and figures. (Kelly 1984). Maccoby and Jacklin (1974) suggest that the undeniable differences in girls' and boys' visual spatial abilities are not actually significant until adolescence. The relationship between spatial awareness and late maturity has been shown to be significant, irrespective of gender.

As boys are generally held to mature slightly later than girls, this may account for their perceived superiority in spatial ability (Waber 1976). The question of visuo-spatial differences is still somewhat speculative. The differential treatment of babies is more likely to encourage the development of gender identity in line with societal and cultural expectations. If the relatively rough treatment of boys in parental interactions does have an effect on the development of visuo-spatial awareness, it has not been categorically proven as yet. It may be that the effects laid down in early infancy manifest themselves in adolescence.

Another factor in the differential treatment of male and female children appears in the socialisation of infants. Parents, subject to cultural and social expectations, either consciously or unconsciously, reinforce or discourage gender appropriate behaviour. This is seen particularly in the selection of toys given to the child and in the sanctions applied for misbehaviour, when boys are given more restricting punishments (Maccoby and Jacklin 1974).

If social and cultural expectations determine parental behaviour towards their children, it is reasonable to assume that teachers are subject to the same social and cultural dictates. Nursery teachers have been found to have different expectations of girls and boys (Hargreaves and Colley 1986). These different expectations will reinforce any gender stereotyped behaviour exhibited by the children. The Nursery teachers' expectations take the form of girls being quiet and compliant and boys being boisterous and noisy. The manner in which teachers deal with the different behaviours exhibited by the children also reinforces gender specific behaviour. The facts that the boys are expected to be noisier and more boisterous and that this behaviour is at odds with that which is expected from the children in the group situations encountered in nurseries and schools, means that the boys tend to attract more of the teacher's attention by their relatively disruptive behaviour. This has implications for a wide range of school activities, particularly practical activities.

Practical activities are dependant on co-operation within a group. The children at primary school tend to work in groups rather than individually, especially for activities which require equipment, which is often in short supply. If a number of the group are not able to stay on task and work co-operatively, the activity that has been set will not be completed and the other members of the group who wish to complete the task will find ways of circumventing disruptive behaviour in order to achieve the end aim. This is generally done by dividing up the tasks involved in the activity.

The relationships that boys form with boys and girls form with girls also has ramifications for practical activities. It has been observed that from an early age (approximately 6 months) girls tend to use more eye contact in their interpersonal dealings. As they become older they tend to form small groups of 2-3 children for their games. Boys of a similar age tend to form larger groups and be subject to a more 'pack' type of behaviour, within which there is a distinct hierarchy (Maccoby and Jacklin 1974, Benenson 1993, Ohrn 1993). This manifests itself in classroom situations, as boys calling out answers and observations and dominating equipment in practical activities. The fact that girls are generally more compliant and 'good' generally means that rather than attracting the teacher's attention they are sidelined and ignored, to a large extent, whilst the rowdier boys are dealt with. This has the effect of making the boys appear more confident, in that they have the courage to interrupt lessons and the attention their disruptive behaviour attracts from the teacher is seen by the pupils as evidence that the boys are more valued, as any attention from the teacher is seen as indicating status; therefore the girls feel inferior and ignored because the teacher's attention is more often focused on the boys (Abraham 1983, Stanworth 1990).

Research from the USA, reported by Stanworth (1990) suggests that;

"pre-school and primary teachers believe their pupils conform closely to gender stereotypes (boys active, aggressive and extrovert: girls passive dependent and introverted)"

p 21

It is possible, therefore, that teachers unconsciously reinforce gender stereotyped behaviour. If teachers expect boys to be more domineering and aggressive, though they reprimand unsuitable classroom behaviour, this has the effect of giving the boys more of their time and attention, at the expense of the girls. Abraham(1986) reported that the girls were aware of this and did not appreciate it, making them feel left out and 'sidelined'. Any expression by the teacher of attention or concern is seen as an evidence of interest (Ohrn 1993). It is reported that,

"all teachers - female as well as male - seem to be particularly responsive to the needs of male pupils"

Stanworth 1990 p 49

The 'needs' of boys in the classroom is probably based in the expectation by the teachers that boys are likely to exhibit disruptive behaviour and therefore intervention is the preferred strategy. There are other factors, such as the fact that boys call out to gain the teacher's attention, they are likely to deploy tactics that ensure the teacher's attention and minimise the work they actually have to produce. The girls in the meantime may need assistance but are less likely to call out for it, rather waiting until the member of staff approaches them directly or finding a suitable quiet moment. Other strategies employed by boys in classroom interactions with girls, which reinforce the teacher's expectations of gender appropriate behaviour, such as moving out of their seats, talking amongst themselves and shouting the girls down, perpetuate gender appropriate behaviour. If the teachers 'know' what to expect from girls and boys it seems reasonable to assume that the children do also. These aspects of classroom interactions have been more widely studied at the secondary level and will be dealt with in more detail in the next section.

There is some contradictory evidence to indicate that boys at primary age are not treated any differently from girls by male or female teachers, though teachers reported the boys to be more troublesome than the girls. This did not seem to affect the boys' ability to perform set tasks nor did it result in any extra attention from the teachers (Merrett and Wheldall 1992). Nevertheless, generally the research seems to indicate that there are differences in experiences in the primary classroom for boys and girls.

These gender-typed beliefs that the teachers are said to hold will exert an influence on the pupils' academic performance (Rogers 1987). Teachers have been shown to operate an 'expectancy effect', whereby pupils who are expected to progress academically actually do so, apparently without any deliberate interventions from the teacher (Rosenthal and Jacobson 1968). Though the research which produced these findings is now in question, it has been shown that there is a clear differential effect of some sort which operates in the classroom, though the teachers themselves may not be aware of their differential treatment of boys and girls (Clarricoates 1980, Sealey and Knight 1990, Lafrance 1991). This effect is particularly important in science lessons especially when combined with the child's perception of itself and its perceived ability. If girls feel that boys are given more attention by the teacher, for whatever reason, in lessons and also hold the belief that scientific activities are 'male' activities, they enter science lessons with a double disadvantage to overcome.

It has been indicated that children have a very good awareness of their own ability as young as pre-school and that by the age of 6- 7 years the children have a clearly defined differentiated view of their own competence at various activities and their ability to perform in particular areas. When asked to rate a variety of activities, girls rated maths as an activity of the least value to them, whereas the boys rated maths second to sport. When asked what activities they felt they should be good at, girls and boys generally said that girls should be good at reading and boys at sport (Eccles 1993). The boys' perception of their ability is generally rated by themselves as higher than it actually is and the girls generally tend to underestimate their ability. A similar difference can be seen in the selection of activities which the children engage in outside school, as hobbies. Boys claim to be more interested in 'tinkering' activities such as playing with constructional and electrical toys, helping their fathers with car maintenance. The girls claim to be more interested in household and nature study type activities. This leads to reinforcement of learning through activities and those activities that are providing the learning experience are said to be:

> *"more likely to provide a broad consolidating base for later conceptual learning in physics"*
>
> Johnson 1987 p 470

Whilst there seems to be a sound basis for suggesting that children in the primary school are generally positive about studying science, there seem to be other factors that are operating to make their interests diverge. This divergence appears to have some basis in the gender of the children and the difference inherent in their upbringing. However, this is not necessarily the whole picture.

Children arriving at primary school at 4 or 5 years old have quite definite ideas as to what they expect school to be like. They bring to school, along with these expectations, behaviours and experiences from their early pre-school years. These will be as wide and as varied as the children themselves.

The school itself has expectations of how children should behave and what they will be taught. For learning to take place effectively, a common ground has to be found between the children's expectations and those of the school. The National Curriculum requires that all children have experience of science. Nursery children are now expected to cover science topics though this has not yet been formally included in the National Curriculum. This places a tremendous burden of responsibility on Early Years teachers. It is their job to ease the children, with their wide variety of backgrounds and experiences, into school and school life. At the same time they are required to present the children with new areas of learning in the parameters defined by the National Curriculum in Maths, Science and English particularly. If the children come to school with clearly defined ideas, their initial experiences will influence their future attitude to school. If these experiences are not positive, in any given area, a precedent may be set and their attitude to that subject area in particular and school in general will be coloured. If early school experiences reinforce ideas that are already held, these ideas become more firmly held.

It has been shown that children as young as 4 - 5 years old hold a stereotypical image of the scientist (Chambers 1983, Schibeci and Sorensen 1983). Therefore if the children have an idea of what a scientist looks like it is reasonable to assume that they must also have an idea of the activities that the scientist is involved in and the nature of his work. If their idea of the scientist is that he is a man, the assumption may well then be that science is a man's world and the work involved suitable mainly for men.

There is a body of research which has found no differences in the children's interests in science, nor in the way children are treated in classrooms (Robertson 1987, Merrett and Wheldall 1992, Koh Aun Toh 1993). The differential treatment of the children in classrooms has been indicated as contributing to consolidating gender differences already exhibited by children, particularly as regards their interpretation of science and scientist.

v) *Secondary School Students' Attitude to Science*

At the end of their primary schooling, children have a positive attitude to science and look forward to studying science as a subject at secondary school. There are differences in the preferences of boys and girls for particular science topics but these differences do not appear to affect their enthusiasm and positive attitude towards the subject itself (Omerod 1981, Hadden and Johnson 1982). A survey of 9 year olds at primary school found that 60% of all the children found science lessons interesting and enjoyable (Yager and Penick 1986).

The initial enthusiasm is seen to wane as the children progress through their secondary education. Their attitude to science becomes increasingly negative, so that 40% of 13 year olds and a slightly lower proportion of 17 year old students, feel that science lessons are exciting and interesting. Many of the older students reported that they feel uncomfortable in their science lessons, a feature reported by very few 9 year olds (Yager and Penick 1986). The polarisation of interest becomes more marked. This is generally evidenced by the statistics showing marked differences in the proportion of girls and boys taking each of the subjects. What is not so readily apparent from the statistics is that the rate of success of girls in physics is slightly higher than that of boys. This is revealed when the numbers of boys and girls enteried for the examinations is compared with the numbers passing and the distribution of their grades -(DFE 1985 - 93). This implies that, though fewer girls may take physics examinations, they actually tend to perform better in physics and less well in biology, than boys when they do. The reasons for this are not clear. Girls in girls' schools tend to be more likely to opt for physics than girls in mixed schools (Kelly 1984). Girls only schools tend to be independent schools which because they are fee paying are therefore only open to a particula sector of society. Girls in mixed schools who opt for physics are more likely to be the more motivated students who are prepared to run the gauntlet of peer group disapproval, by opting for a 'boys' subject and who also feel confident enough to study a 'hard' subject.

The introduction of the National Curriculum Science courses should ensure that all 14 -16 year old students study some science and thus leave school with a core of scientific knowledge. There is still the possibility for science to be deselected at 'A' level by those students who opt to stay at school. At this point, choices made by students at examination level are determined not only by the career they wish to pursue but also by the experiences of particular subjects throughout their secondary school education. There may be a number of issues involved, the type and content of lessons, peer group pressure exacerbated by adolescence, the gender of their teachers and the type of school. These issues will be discussed in this section.

The introduction of the Single and Double Award science examinations in 1991 reduced the numbers of pupils taking other types of science courses, General Science and Rural Science, for example. More or less equal numbers of boys and girls achieved Double Science Awards, whereas more girls than boys opted for and achieved Single Science Awards.

Girls' relative lack of interest in studying science at higher levels and entering science and engineering careers has been a cause for concern for a number of years. Table 4 illustrates the numbers of students achieving 'A' level science and maths subjects. Research into the underlying causes has as yet, produced no conclusive evidence as to the reasons for the general decline in interest in science courses. Areas of concern have been identified, such as the lack of girls taking science courses and the unpopular image of science. Research has indicated ways forward, such as attempting to remove any gender bias to make science more 'girl friendly' (Smail, Whyte and Kelly 1987) but this does not seem to have altered the situation to any large extent, and the popularity of science continues to decline.

Table 3. Girls and boys passing at 'A-C' grade in science subjects at GCSE (15 years old) (Numbers in thousands)

	Maths		Physics		Chemistry		Biology		Other Sciences	
	b	g	b	g	b	g	b	g	b	g
1985/6	122	98	80	33	58	40	46	66	65	13
1986/7	119	97	80	32	58	40	45	65	62	16
1987/8	121	97	73	31	55	38	43	63	64	19
1988/9	115	97	68	31	53	40	40	58	27	25
1989/90	107	94	55	26	42	33	33	48	41	42
1990/91	108	98	40	19	34	25	25	32	54	51
1991/2	104	99	25	12	21	15	18	19	3	2
1992/3	105	102	22	11	20	13	19	16	3	2

Source: DFE (1985/93)

One of the original pieces of research which identified the stereotypical image of the scientists as male and science as a masculine discipline, also identified a number of possible reasons, which have been used as the basis for further research (Mead and Metraux 1957). Much of the research is driven as much by governmental concerns as by academic interest. The lack of interest in science and engineering courses means that the adult workforce is seriously depleted and in the modern era of equality for all, the lack of women taking up careers in science and engineering is seen as a problem that needs addressing. People who have little or no scientific knowledge are disadvantaged and reliant on those members of society who have such knowledge in many areas from the domestic to the political arena.

Table 4. Passes at 'A' level (Numbers in thousands)

	Maths		Physics		Chemistry		Biology		Other	
	b	g	b	g	b	g	b	g	b	g
1985/6	28	13	23	6	18	10	9	12	4	1
1987/8	29	14	21	6	16	10	9	13	5	1
1990/91	24	13	19	6	15	11	9	14	1.34	0.82
1991/2	26	14	18	5	14	10	10	16	2	1

Source: DFE (1985/93)

A survey of the general public's understanding of science conducted in Britain and the United States of America in 1988 suggested that though a majority of adults claimed to be very interested in science, their actual knowledge of the scientific facts was uninformed. The people most likely to have an informed knowledge of scientific facts were young, middle-class men. Women tend to be less interested and involved in science than men (Durant, Evans and Thomas 1989). If this is the case, it reinforces to some extent the stereotypical image of science and the scientist, identified by Mead and Metraux in 1957 and seen again by Weinreich-Haste in 1981.

The lack of women scientists is only part of the problem. As girls are more likely than boys to opt out of science courses at school after GCSE , or to have a negative attitude to the science they do study, girls are more likely to leave school with only a moderate amount of scientific understanding. This has serious implications for the adult population in general. With one half of the population more likely to have greater scientific knowledge than the other, this effectively puts those with more scientific knowledge in a position of power, particularly in today's increasingly technological society. Therefore, the proportion of the population who lack science education, the women, are disadvantaged and dependant on the proportion of the population in possession of knowledge (Weinreich-Haste 1981; Walkerdene 1989, Durant, Evans and Thomas 1989).

If children enter secondary school with a positive attitude to science but a divergence in interests, it would be expected that these particular interests would continue as their studies increase in depth. In fact the interest in science is seen to decline across all three scientific disciplines. There are a number of factors that have been implicated as contributing to this general decline in interest in science as the students progress through their secondary education.

We have already seen that the social and cultural expectations of society, imposed by parents and teachers and their peers, have a profound effect on the children's attitudes (Maccoby and Jacklin 1974, Bennetts 1989, Öhrn 1990, Bentley and Watts 1994). It might be expected that the gender polarisation would continue to some extent as the students move through adolescence. In fact, the polarisation effect is enhanced by the onset of adolescence, which coincides with entry into secondary school.

The polarisation in perception is seen in the suitability of some science topics for boys and others for girls . The children have already developed different areas of interest during their primary years, with the girls being more interested in biologically based science topics and the boys favouring physical sciences. This division of interests appears to become increasingly polarised to the point where girls feel that physics is a boys subject and boys feel that biology is a girls subject. Chemistry seems to be only slightly biased towards the boys. This is despite the fact that at the age of 11 years, on entering secondary school, the majority of students are looking forward to studying science generally (Kelly 1981, Omerod 1981, Hadden and Johnstone 1982)

Very often secondary school laboratories are dull uninspiring places full of strange equipment and distinctive smells. This is usually in complete contrast to the students' previous experiences of science lessons and must cause them to wonder what sort of lessons will be conducted in such places (Ramsden 1990). This fact, combined with the content of science courses, may be sufficient to cause a negative interest to develop in both boys and girls. Science lessons that are composed of a large amount of factual and mathematical elements delivered by men in laboratory coats, further increase the students' scepticism , particularly about physics and chemistry.

Young people are aware of the social expectations of their gender. By the time they reach secondary school they have clearly defined ideas as to which areas of activity are appropriate for girls and boys. Boys particularly, seem very aware of the need to avoid any behaviours or attitudes which may be construed as feminine and to that extent they could be said to be more aware of gender appropriate behaviour than girls. Girls seem to be more able to participate in some male appropriate activities. Appropriate behaviours and activities affect the way school subjects are seen, so that some subjects are designated as girls subjects and others boys subjects. Children who opt to study gender inappropriate subjects are thought of as effeminate in the case of boys or very clever in the case of girls (Walkerdene 1989, Stanworth 1990). An extension of the awareness of gender appropriate subjects, is the type of work adults do. A survey of children's ideas about the gender appropriateness of a variety of jobs showed that they saw clear distinctions between men's jobs and women's jobs. This survey was undertaken as part of a larger project which also looked into the gender perception of various school topics (Kelly, Whyte and Smail 1987). The jobs and school subjects and their gender allocation as by Kelly, Whyte and Smail (1987) are reproduced in Tables 5 and 6.

Table 5. A summary of the gender stereotyping of occupations (from Kelly 1982)

Occupation	female score	male score
secretary/nurse	3.20	
making clothes/ cleaning/ receptionist	2.20	
hairdresser	2.30	
cashier	1.20	
primary teacher/ waitress/English teacher	0.40	
novelist / maths teacher	0	0
scientist		0.80
dentist		0.90
surgeon		1.10
doctor		1.20
lawyer		1.80
window cleaner		2.10
airline pilot / astronaut		3.00
engineer/ army officer		3.20
making cars		3.70

Table 6. The Gender of School Subjects as Perceived by Adolescents (Kelly 1982)

Subject	Gender interpretation of subjects	
Maths	male	
Physics	male	
Chemistry	male	
Geography	male	
Biology		female
Languages		female
Arts		female

The jobs that are seen as appropriate for females are generally those of a caring capacity, nursing, teaching, hairdressing. This accords with the image of the Western woman, whose role is seen as that of the family carer, despite moves by feminists to alter this perception (Weinriech-Haste 1981, Walkerdene 1989). The fact that jobs are seen by young people as being gender appropriate, influences the subjects that the girls choose to study in order to pursue a career in areas seen as female . The majority of jobs in these professions have not previously needed a high level of scientific qualification or expertise.

Domestic tasks are seen as female tasks. This accords with the perception of women raising and caring for the children. This may be changing in modern society, as more women go out to work and some men opt for the caring role at home. Generally despite changes, this is still the model that society views as appropriate for women. This is part of the behaviour which is designated female behaviour. It has its basis the basic biological function of child bearing and rearing. Females who transcend the role models imposed by a society are seen as being at odds with that society (Kelly 1981, Walkerdene 1989, Whitehead 1994).

Adolescence is a time of great change both physically and emotionally. Young people are beginning to assert their position in society and this involves acknowledgement of gender appropriate behaviours. There may be an exaggeration of these gender appropriate behaviours as adolescents mix with their peers and assert themselves within these groups and prepare to enter adult society. Boys may actively avoid any behaviour which could be interpreted as being feminine and to some extent girls may avoid masculine behaviours.

This is seen in the subjects that the students choose to study. The survey above indicated that physics is generally seen as a male subject, whereas biology and the arts and languages are seen as female subjects. Therefore girls may opt not to study physics because it is seen as more appropriate for boys. In addition to the gender appropriate perception of particular subjects is the additional factor that if a subject is seen by girls as being more appropriate for boys, they feel they will consequently find studying the subject hard. This applies particularly to physics. Physics is an academically difficult subject in reality and has a fundamental mathematical foundation. It is perceived by students as a difficult subject to study. Boys generally have a higher opinion of their academic ability than measurement would indicate as valid and view difficult subjects as more interesting (Walkerdene 1989). Therefore they are more likely to opt for physics as being within their capabilities and interest. They are also likely to indicate that physics is not appropriate for girls. This they do in a number of different ways (Galton 1981, Walkerdene 1989).

It has been seen that even in the primary school boys tend to dominate classroom proceedings in both overt ways, primarily by being noisy. They also dominate equipment collection and do not necessarily follow instructions accurately, in that they may find alternative uses for the given equipment. If they are in a group with girls, they will dominate practical activities, leaving the girls to perform the 'housekeeping' tasks, such as taking measurements, writing and recording. These phenomena are seen in older students. The boys still dominate activities, tending to monopolise equipment and relegating girls to observational roles. They attract a great deal of the teacher's attention by calling out, leaving the girls feeling undervalued and incompetent. Girls are less likely to call out in the classroom situation if they have a problem. They are more likely to wait for the teacher to approach them or for an opportunity to approach the teacher. They are therefore likely to pass an entire lesson with their problems unsolved if they are unable to attract the teachers' attention. This of course should not be the case as teachers should be aware of all the students, but in reality teachers tend to solve the immediate problems as they arise. Hence the boys succeed in dominating (Walkerdene 1989, Stanworth 1990, Abraham 1995).

In the lower years of secondary education, students tend to work in groups for practical science activities. If these groups are mixed there is a division of labour within the group. This division of labour tends to leave the girls with the recording and writing up of the experiments, whilst the boys actually do the practical activity. The girls are therefore adopting, by choice or default, a passive, observational role. This factor has been seen to a lesser extent in the primary sector. Where the groups are not mixed, that is, there are groups of boys and groups of girls within the same laboratory, the girls still tend to be disadvantaged in that the boys tend to take all the effective equipment first. This leaves the girls with either no equipment or with inferior equipment which may be faulty, therefore they are unable to complete the task effectively. In situations where there is a fair division of equipment, the girls can match the boys in performing the activities (Koh-Aun Toh 1993). Girls' work tends to be neater, one of the reasons stated by boys, for them taking on the recording and writing up role in mixed groups, and often the presentation of their work is superior to that of the boys, leading to a clearer interpretation of the activity.

The fact that the girls so often take a non-active part in the actual performance of experiments is seen as their adoption of the traditional behaviour expected of Western women, that of being passive. Any girls who do not conform to this role may find themselves at odds with the boys and also their female peers. Adolescence both for girls and boys is a process of defining their gender identity.

> *"The image of a scientist is in direct conflict with society's ideal of womanhood."*

Kelly 1982 p20

Not only do the girls tend to lose out on the allocation of equipment because the boys are domineering when selecting, they also tend not to have as much experience in the use of equipment outside the school laboratory. A survey of the types of equipment that children had used out of school showed that boys had more experience of a wider range of measuring instruments as a function of the types of hobbies and activities they engaged in outside school. The survey is reproduced in Table 7.

Table 7: Percentages of boys and girls reporting the use of instruments outside school (APU 1987)

Measuring Instrument	% 11 year olds	
	boys	girls
Compass	69	48
Microscope	49	34
Stopwatch/clock	66	52
Spring Balance	28	20
Hand lens	70	59
Metre Stick	22	16
Thermometer	53	49
Weighing scales	75	81

It would seem therefore that girls are noticeably disadvantaged in science lessons, because the type of equipment they are likely to come across in some scientific activities, particularly in physics, is already more likely to be familiar to the boys from their out of school activities. The activities that boys engage in outside school and through their early childhood would seem to equip them better for science as it is studied in school. Their familiarity with the equipment and techniques for using it when they arrive at school, is seen as a distinct advantage in that they have little anxiety about its use.

Society's conventions suggest to girls that they should be feminine and exhibit feminine behaviour. Girls anxious to be accepted by their peer group conform to these pressures as they progress through adolescence. A part of this conforming is the avoidance of activities which would suggest that they are not wholly feminine. Science is regarded as a male orientated subject. As such it is not suitable for girls. Thus, it is argued that girls will not be very good at science, particularly physics. Science, particularly physics, is regarded by boys and girls as a 'hard' academic subject. Girls feel that they are not able to undertake the study of 'hard' subjects. Boys on the other hand, regard themselves as more able to undertake difficult subjects. Boys tend to over-estimate their academic ability, whereas girls tend to underestimate theirs.

Schools tend to polarise girls and boys in many ways. This is particularly evident when groups of children are divided for activities. Gender is one of the easiest distinctions to make in a diverse group of children (Gardener 1984). This polarisation effect reinforces the gender appropriate behaviour that the adolescents feel is so important to them, by highlighting the different genders. Of course this fact cannot be operative in single-sex schools. The pupils will still be adolescents and they will still be aware of the gender appropriateness of particular activities and subjects; there will not necessarily be the same pressure to conform to the 'ideal' as there are no members of the opposite sex to contend with. This could mean that there may be a different approach to science in girls schools from boys schools. Consequently, girls may feel able to pursue science subjects, physics in particular, and boys may feel able to study biology, without overtly appearing to cross the gender divide and alienate their peers.

vi) Primary Children Doing Science

If primary age children have a definite idea who a scientist is, then they probably also have a clear idea about who does science. Early social conditioning and classroom activities since arriving at school, dictate and reinforce the 'social norms' of appropriate male and female behaviour and tasks.

An interesting study by Ann Qualter and Eileen Taylor (1992) illustrated this quite clearly. They asked 120 primary school children aged 7 - 13 from 3 very different types of school to complete 3 worksheets. Two of the sheets required the children to match pictures of boys and girls to a variety of tools and instruments. The vast majority of children (112 out of 120) matched the faces to the tools in the same way; that is in a gender appropriate or what they, the researchers considered to be gender appropriate. Thus the boys were matched with hammers and computers and the girls with mixing bowls (for cooking) and craft materials. The choice of pictures and instructions may have been divisive in that the children were only allowed one option per picture, thus not allowing for the children to put both.

A third sheet asked the children to divide a number of 'jobs' in a science experiment between four children, two girls and two boys. All the practical tasks were given to boys whilst the drawing and data recording were seen as appropriate for the girls. This gender division for 'jobs' in practical activities has been noted before at both primary and secondary levels (Qualter and Taylor 1992).

This idea that practical science tasks are more suitable for boys is confirmed by a two year study of 29 children in the final year of their primary school in Ireland (Morgan 1989). The boys were interested and enthusiastic about the practical aspects of science but less so about writing their ideas down. Interestingly, Morgan found that the girls fell into two groups, those who were interested in the scientific experimental investigations and those who were not. Generally it was the younger girls who showed the most interest in the investigations. If young children hold the view that practical activities are the domain of boys, they are likely to have formed these ideas probably before they enter school and their school experience has only served to reinforce their ideas.

The 1984 Assessment of Performance Unit (APU) science monitoring discovered that by the age of 11 years there was a distinct dichotomy in the children's preferences for science topics. Girls tended towards biological subjects and the 'aesthetic' elements of weather and colour and boys tended towards electrical circuits, speed and materials (Johnson 1987). These preferences for science topics were reflected in the choice of their out of school hobbies. The girls tended towards activities connected with domestic activities and nature study and the boys towards model making, dismantling mechanical objects and playing with constructional and electrical toys (APU 1984, Johnson 1989).

These so called 'tinkering activities' which the boys indulge in out of school, may provide a basis for their activities in school science, particularly at a primary level, and this in turn may influence general perceptions of the subject of science (Hadden and Johnson 1982). On the other hand the activities that the girls prefer, though not giving them practice in the use of equipment generally found in primary schools, bulbs and batteries for example, may actually be preparing them in a broader sense for science in a wider context.

That the 'tinkering activities' better fit boys for practical science activities is reflected in the reported use of 'scientific' measuring instruments outside the home. Boys report using compasses, microscopes and stopwatches with more frequency than girls. Girls on the other hand are more likely to have used thermometers and weighing scales. This is found to be consistent in both British 11 year olds and American 9 year olds (Johnson 1987) (See Table 7 page 76).

Performance tests intended to measure children's ability to apply scientific concepts show significant gaps in performance in favour of boys for physics and to a lesser extent in chemistry and biology at the age of 11 (Johnson 1987).

Children entering primary schools have preconceived notions of their place in society and what society expects from them in terms of gender appropriate behaviour, and a construct of the world as they see it. This is an inevitable consequence of the socialisation process and its impact on children. Moves to make masculine subjects accessible to girls, though worthy, are fraught with inbuilt difficulties. Girls arrive at school 'disadvantaged' in the sense that their early play activities have predisposed them to difficulties in science activities in that they are less familiar than boys, with the equipment they will be confronted with. On the other hand, if they do spend their time in female activities such as cooking, they will actually have developed a great many scientific skills. The knowledge that an organised and logical approach is necessary to complete a recipe for example, is a very useful skill for approaching the organisation of scientific investigations. Therefore they may not be as disadvantaged as some researchers have stated (Johnson 1987, Koh-Aun Toh 1993). The factors that tend to make them reticent about practical work would therefore be more likely to be of a more complex nature.

One of these factors could be the daily classroom interactions. As already stated, the children arrive at school with ideas about their gender, their ability and which behaviours are appropriate for them. The teachers also have expectations of the children which are in part gender specific, namely girls are good and compliant and boys are noisy and boisterous. Conscious or unconscious reinforcement of these teacher expectations confirms and reinforces the children's ideas. This process begins in the nursery school and continues through primary school. It is further reinforced in other areas such as lining up - a girls line and a boys line. This 'hidden' curriculum may have an effect on the rest of the activities the children undertake in school.

Nevertheless, primary age children appear to enjoy practical activities in science, although the girls may feel that 'masculine' activities, such as those involved in topics such as electricity, are more appropriate for boys and therefore state that they find them difficult. The fact that girls and boys have been observed to have preferences for different areas of science, boys physical and mechanical science, girls biological science, does not seem to have an effect on their overall enthusiasm for practical science activities (Omerod 1981, Hadden and Johnstone 1987).

vii) Secondary Students' Doing Science

Children and teachers have an expectation that science lessons should be of a practical nature. Children tend to react negatively if the lessons do not have a sufficient practical aspect (Woolnough and Russell 1991). 'Doing science' at the secondary level of education becomes more than an exercise in scientific experimentation. The practical aspects of science lessons are generally the parts that students say they enjoy the most, preferring them to note taking and demonstrations (Ebenezer and Zoller 1993). Practical work in the early stages of secondary school is usually executed as a simultaneous exercise in groups. The size and structure of the individual groups varies from school to school, and is dependant on the allocation criteria used by the teachers. Thus groups can vary from two students to half a dozen. Any group which has to work together on a project, needs to be able to communicate and co-operate. Thus a measure of social interaction must take place.

Solomon (1989) points out

> *"'Doing science lessons' is a social activity which is governed every bit as much by the rules and rituals of group activity as by the exposition and questions posed by the teacher."*
>
> Solomon in Millar p 126

Secondary education coincides with adolescence. Adolescence is a period of great change, testing of ideas, rejecting and accepting codes of behaviour in the transition from child to adult. All these aspects of adolescence come into play during secondary schooling and affect the way the students interact with their peers and their teachers and perform in lessons.

It has been seen that group work in the primary school is not entirely effective, as boys tend to dominate the practical activities, by dominating the equipment and the teachers' time. Science experiments and investigations require that the children work co-operatively, which some children find difficult. The National Curriculum Sc1, requires that the children design and conduct investigations. This requires a high degree of co-operative working. The division of tasks that was observed in the primary school is seen again in the older children. The girls are given the recording and writing tasks and this allows them to opt out of the practical activity. Careful organisation of groups can, to some extent, counter this effect.

At the secondary level, group work, can be an effective forum for scientific discovery, as both boys and girls contribute their differing perspectives to activities. Practical work was advocated by the Nuffield 13 - 16 scheme when it was introduced in the 1960's. The idea was that the students were 'scientists for the day' and aimed at developing a 'scientific' method of thinking and working, rather than purely acquisition of a body of facts. In order to achieve this the students worked in groups.

There are two possible reasons for the divisions of labour commonly seen in school science groups. One is that the girls may feel that they are not as competent as the boys to perform the science experiments, because they see science as a boys subject. Also they may not be as familiar with the equipment. Second, girls tend to be neater and more organised with the presentation of their work than boys, which lands them the job of recording results and writing up of the activity. Whatever the reasons for the distribution of the work load within the groups, the fact is that there are such divisions. The problems that arise out of the divisions are actually far reaching, in that the girls are reinforcing their feelings of inferiority by seldom attempting to do the practical work and allowing the boys to dominate this aspect of practical lessons. The boys on the other hand, though reinforcing their application of practical skills, are not actually producing any written work. This has been said to be a deliberate ploy on the part of the boys, who not only are less tidy than the girls at written work, but are also more reluctant to produce written work.

In addition to these factors are the very real problems of social interaction associated with adolescence. As the children progress through adolescence, they become increasingly aware of the roles they are expected to adopt in respect of their gender. In order to be seen as complying with these roles the behaviour exhibited is often seen in an exaggerated form. Boys particularly, tend to actively avoid any forms of behaviour that may be interpreted as effeminate. Girls also prefer to pursue activities and behaviours seen as appropriate to their gender, but are not as prone to ridicule by their peers as boys who exhibit gender inappropriate behaviour.

A study which investigated the reasons for girls' reluctance to participate in scientific activities and seek methods of redressing the problem was conducted by Smail, Whyte and Kelly (1987). Given the acronym of GIST, the 'Girls into Science and Technology' project looked at a number of aspects of science education, concerning itself mainly with the causes of female underepresentation in science and technology and looking at ways to change the situation.

The study determined the causes of underachievement by girls as being attributable to;

i) the perceived difficulty of physics

ii) the absence in science studies of social or human implications

iii) the girls' relatively more limited experiences with scientific and technical toys and games

iv) the expectations of the girls' future lives

v) the paucity of role models of women in science and engineering.

p2

Many of these factors have already been identified by other researchers and have already been mentioned. The focus of this chapter is the children's readiness to perform practical tasks and their views about doing so.

In 1987, the GIST project found that of the female students leaving school, 80% had only one scientific qualification, which was usually biology. This has serious implications for the future careers of female students as their lack of scientific qualifications deprives them of entry to a large range of occupations. This may not be a problem if the girls have actively deselected science because they don't enjoy the subject; they are less likely to wish to pursue a scientific career. In 1981 the female life chances were seen as being reduced to one of 6 possibilities:

i) teaching - especially primary

ii) nursing

iii) catering

iv) office work

v) retail organisations - shop assistants

vi) hairdressing

This leads to cultural assumptions about 'men's work' and 'women's work', which is further reinforced by the different qualifications of males and females when they leave school and reinforced again on a personal level when women are unable to understand and therefore mend kitchen and household machinery, making them dependent on men. Men on the other hand, whilst generally thought to be able to mend the items generally thought of as equipment for females, appear to be thought of as unable to use the said items. Is this a case of selective ignorance perhaps? The rise of feminism, is perhaps reversing the actual situation, though this does not necessarily effect the general concept held by society. That will probably take much longer.

As the main carers of children there is also a problem for women in that their relative lack of scientific knowledge makes them dependent on the portion of society that is in possession of the knowledge (generally the men) and this is particularly important when women have to make decisions affecting their children, such as water fluoridation, food additives and the use of pesticides on food they prepare for their children.

There is also a problem for teachers, in that if such a large number of girls are choosing not to pursue science at school there must be factors in operation which are influential in causing this. The perception of school science is different from that of science in the public arena and is thought to be influenced by the curriculum implemented by the school, the teacher's image and behaviour towards the class, the national culture and current climate of social beliefs and the teacher's preparedness for teaching science (Hofstein, Sherz and Yager 1986). The introduction of the National Curriculum should have gone some way in redressing the differing curricula implemented in schools. The teacher factor will be dealt with in the next section. The national culture and current social climate encompass the features identified by the GIST project as being potentially influential in discouraging girls.

When children leave their primary schools boys and girls appear to be equally enthusiastic about science. Boys have been shown to have a more positive attitude to practical work and as they progress through their secondary education are shown to have a significantly more positive attitude towards science (Harvey 1985). This is despite a more negative attitude to school in general shown by boys. Within the school and classroom there are social norms which reinforce and underline gender divisions. Subjects are attributed a gender bias, in the case of science, a masculine bias. This puts a

"firm but subtle pressure on the girls to take a back seat"

Harvey 1987 p37

Also boys are said to think that girls who wish to study science are a 'bit peculiar' because learning science is more important for boys. To add to this there is the fact that the language of science can be different from ordinary language. The use of scientific words and the presentation of scientific theories, tends to give science an air of authority which does not appeal to everyone and may in fact make science appear more complex and difficult than it actually is. The complex language of science is thought by some to be a barrier behind which scientist and science teachers hide to protect their perceived superiority (Russell and Munby 1983). Boys tend to feel they are good at difficult subjects and therefore they are good at science. Often this perception is misguided and boys find that they have to work very hard to achieve results. Nevertheless this perception may be sufficient to deter girls.

Despite efforts to alter the situation, many science text books tend to be written from the perspective of boys, assuming a male audience and masculine interests. This carries a hidden message that science is really for boys. The constructivist view of children's learning, which dominates science teaching at the present time, has arisen from the recommendation in the Plowden Report and the Nuffield initiatives. If we look at the constructivist standpoint, that learning should take place from the perspective of the children and be relevant to them, the messages that are given to the children from text books, social assumptions and practical activities, tend to reinforce the masculinity of science. Pupils have already formed their own ideas of scientific phenomena and take these ideas to science lessons. Therefore in order to make the lessons more relevant for girls, the question of text books, activities and teacher presentation need to be addressed. In addition to this the

> *" boys and girls face different cultural*
> *and institutional conditions and relate*
> *to the social environment in different ways"*
>
> Öhrn 1993 p148

The dichotomy of interests that existed when the children started secondary school continues to exist and begins to extend to encompass a wider range of issues. The girls still tending towards biological sciences connected:

> *"with issues of health and the human body and aesthetic aspects of weather, colour and music"*
>
> Johnson 1987 p 468

Boys tend to show a greater enthusiasm for finding out how things work. Several studies have sought to identify areas of practical science of interest to boys and girls. Commonly the studies found that girls do enjoy studying the human element of biology such as testing hearing, the eye and growing seeds and parts of plants. The aesthetic topics, such as colour in physics and chemistry, where this translates into chromatography, tie dying, crystal formation, extracting plant scents and making sounds are cited by girls as their favourite and most enjoyable science topics. Boys on the other hand tend to be more interested in electrical circuits and electronics, batteries, air pressure, chemical elements and material, acceleration, soil testing and mechanical experiments such as testing breaking strains (Kelly 1988, Johnson 1987, Erikson and Erikson 1984, Ebutt 1981, Robertson 1987, Whyte 1984). This difference in preferences is along the same lines as was claimed to have been observed in younger, primary age children. It is sufficient to indicate that there is little in pure physics that appeals to the girls. The aspects of science which do appeal to girls are those which could be interpreted as conforming with the Western view of women, thus

> *"for girls, there is a conflict between the overt curriculum of achievement and a hidden curriculum which represents 'appropriate' characteristics and qualities for womanhood"*
>
> Weinriech-Haste 1981 p 219

This presents the girls with a dilemma. They seem to have a predisposition towards the humanitarian, aesthetic elements of science and this translates most easily into biology, which could be said to deal with aspects which girls find more appealing. Physics and to a lesser extent chemistry could be viewed as analogous to detective work, seeking a cause for an effect, using open ended science tasks, which appeal more to boys than girls (Hodson 1993). In science groups boys are seen as more willing to explore and experiment with equipment and they are more forward in discussions. This tends to mask the fact that girls are just as likely to contribute with insight and interest if specifically asked or encouraged (Morgan 1989). By ascertaining the children's interest and starting from that point, and developing, practical work particularly, in line with those interests, as advocated by the constructivist movement, it may be possible to link girls' interest in science to activities they have hitherto felt are inappropriate.

viii) The School Effect

If girls view science as a male activity and a masculine subject, there is a possibility that girls in girls schools may feel differently if they are in an all female classroom. Teaching staff in girls schools tend to be mainly female. If there are any male teachers they are often the mathematicians and scientist. Primary schools are staffed in the majority by females. Staff who have responsibility for the science curriculum and teach the majority of science lessons are often male members of staff if there are any present. There are few single sex primary schools which are state run. Single sex primary schools tend to be exclusively found in the independent sector. This brings into account a socio-economic factor, in that independent schools are normally fee paying schools, therefore parents tend to be from the AB1 social groups. Much of the research into the effect of schooling, therefore has concentrated on the secondary sector of education, where there is a range of different types of school.

The fact that in primary schools and girls schools the science staff tend to be male, carries a dual message for the pupils. The girls who already feel that science is a male discipline have this perception confirmed by the absence of female staff. Those girls who wish to study science, particularly at the higher levels, may not be able to do so in some disciplines as female science staff tend to have qualifications in biological sciences, thus reinforcing the message that physical sciences are not appropriate for females.

The evidence for differing opportunities for boys and girls in different types of schools comes mainly from the secondary sector and is based on GCSE ('O' level) and 'A' level examination entries and results. There is little evidence at the present time of the effect of the type of school on attitudes to learning, the subjects pupils study and academic achievement of younger children. The Standard Assessment Tasks (SATs) which are now in place as part of the National Curriculum, at 7, 11 and 14 years of age, may in time be used in the same way as the secondary school examinations, to assess academic performance in key subjects such as science.

Comparisons made between the number of boys and girls opting for science subjects at GCSE ('O' level) and 'A' level show a difference between the different types of schools. A disparity in performance in Maths, English, Science and French was identified by Dale (1974). Maths and Science are rated as masculine subjects and French and English as female subjects. The boys performed better in Science and Maths and girls performed better in English and French. The subject preferences were confirmed in a study of nineteen secondary schools, and found to be more marked in co-educational schools (Omerod 1975). A later poll of subject preferences, in 1981, confirmed that the division still existed but that it was less affected by gender bias in single sex schools, thus confirming the findings of Dale (1974) and Omerod (1975) (See also Pratt 1984). More recent research studies suggest *"that the single sex environment is superior to the co-educational environment for promoting increased science achievement by girls"*

Young and Fraser 1990 p 5

Whilst girls may benefit academically from being educated in single sex classrooms, boys' performance is improved by being in mixed gender classes. There still appears to be a diversity of interests among pupils in single sex schools, but girls are more likely to view physical sciences more favourably than their co-educational counterparts (Omerod 1987). This could be due in part to their feeling more confident in their learning environment without the influence of boys and the hidden agenda their presence brings into operation. Girls in mixed gender groups have been found to ask more questions in contexts where they feel they are likely to have success, such as French lessons, whereas they appear timid and reluctant in situations where they are in the minority, such as science and maths lessons (Abraham 1993).

On the other hand previous studies found that, when adjusted for ability, examination results showed only a marginal increase in academic achievement science by girls in girl's school and boys in mixed schools.

"The results of the science survey does not give any support to the claims that, in general, girls only schools lead to a large improvement

in science performance of girls. Neither is there any evidence of a general increase in the uptake of science in girl's schools."

Bell 1989 p202

This supports the findings of the Equal Opportunities Commission survey of 1983 which found that after the adjustment for ability, examination results showed only a marginally better academic outcome for girls in girls schools and boys in mixed schools (Bone 1983). This has been seen as the continuing trend in the report from the Equal Opportunities Commission for Northern Ireland (1995), which found that the balance is now being redressed and girls are becoming more positive about science and beginning to reject the traditional stereotypes

These two contrasting viewpoints need clarification. Recent research suggests that different achievements in science by boys and girls appear to be wider in some schools, but the differences in achievements in physics and biology are not as great as the effect caused by different schools. The effect on differing academic achievements of children in different types of school appears to be greater at 14 years old than at 10 years old (Young and Fraser 1994). This would tend to support the argument that the decline in interest in science occurs once students have embarked on their secondary education.

Assuming that girls achieve better results when they are educated as a single sex group, it would seem reasonable to assume that if the pupils are separated for science lessons this would lead to improvement of performance for girls. The Girls into Science and Technology (GIST) project (Smail, Whyte and Kelly 1987), having identified the poorer performance of girls in mixed classes, monitored a number of schools in which science lessons were taught in separate classes of girls and boys. In general, they found that the performance of the girls improved and slightly more girls opted to take physics at a higher level. The segregation of the sexes for science lessons is not always practical in terms of staffing and laboratory availability, but the GIST project results seem to verify the findings of Dale (1974). Other interventions introduced by the GIST project involved exposing girls to role models of female scientists as physical science is taught mainly by men. It was found that the girls' attitude towards science became slightly less gender stereotyped. This would support the view that girls in single sex schools have a more favourable attitude to physical sciences (Omerod 1981).

Again there is evidence to refute these findings. A study conducted in nineteen secondary schools of types ranging from mixed to single sex, state and independent, found that there appeared to be no advantage in forming single sex teaching groups within mixed schools (Harvey 1983). Boys are still more positive than girls about studying physical sciences. One factor that all the studies found was that socio-economic background seemed to be significant.

Independent schools in many countries tend to be single sex and recruit students from higher socio-economic backgrounds. Year 12 (age 17) Australian students, both boys and girls, were found to achieve higher scores in physics when they came from advantaged back grounds and attended independent schools (Young and Fraser 1994). The GIST survey found that girls whose mothers work were more likely to opt for active careers in non-traditional female fields, such as science. Therefore it would seem that,

> *"student gender by itself and in combination with other factors affects how students are schooled"*
>
> La France 1991 p10

ix) *<u>Where do the ideas come from?</u>*

It is apparent that children of all ages have well formed ideas about science and scientists. Perhaps the two are inextricably linked and whilst children view the scientist as a relatively (to them) old man working studiously in his laboratory, wearing his white coat, on experiments of unimaginable complexity, they will view their science lessons as footsteps along the path that leads down the road to the intense world of the science laboratory. Topics within their science studies that seem slightly difficult may assume an air of extreme difficulty and therefore be seen as beyond their comprehension.

Teachers, particularly in the primary sector, whose understanding of science and attitudes to science developed when they were at school, mirror those of the children they are currently teaching. They cannot hope to instil an open and exciting image of science whilst they still view scientists as highly intelligent and science as difficult and beyond their reach.

The media can largely be held responsible for the perpetuation of the 'standard' (stereotypical) image of the scientist. Bassalla (1976) undertook a survey of television and comic book consumption of American children. The 'mad' scientist was found to be well represented. This image, of the scientist in his laboratory with racks of bubbling test tubes, working on world changing experiments, pervades children's imagination from the earliest age.

Schibeci (1986) confirmed these findings and added that the situation was more a cause for concern in recent years due to contemporary children's increased access and exposure to television. The influence of television on children's behaviour and thinking is an area that is beginning to attract attention, as the media report a decline in behavioural standards of children and the increase of access to many formerly adult only entertainment in the form of satellite television channels, videos and the internet on computers.

Bassalla (1976) proposed that the American impression of the "scientific community and its works" was formed by the images portrayed on television, in science fiction novels and on feature films (Schibeci 1986). Sagan (1987) believed that the image portrayed on Saturday morning children's television was damaging in terms of the message given to the young audience, of science being dangerous in that scientists were portrayed as

"moral cripples driven by a lust for power"

Sagan p6 in Schibeci 1989, p141

Australian television appears to show the same images, according to Schibeci (1986). These studies were conducted 10 - 18 years previously, yet a glimpse of British children's television, particularly the cartoon type of programme, shows the scientist in the same guise. At the present time there seems to be a focus on paranormal activities, with programmes of semi-factual nature, as well as documentaries and fiction, portraying scientists trying to explain the inexplicable. And of course there are the various space projects such as the Mars landing and the Mir space station. These types of activities must confirm the impression of scientists formed by the general public. That this guise is one of a stereotypical scientist or what Bassalla (1976) terms a 'pop scientist', is probably due, he argues to the hidden nature of the modern scientist's work. This can no longer be the case, as there has been a growth of television programmes particularly aimed at bringing science to the nation and particularly to children in recent years. There has been a tremendous expansion of 'hands on', interactive, science exhibitions in museums and galleries across the country. It would seem that science has never been so accessible to so many people. Schibeci (1986) noted the vast number of 'informal avenues' for science education but maintained that television was the most powerful due to the amount watched.

This is probably even more true now. According to the General Household Survey (1996), over a period of 10 years the number of viewing hours available has increased from 70 to 430 hours per day and video sales have increased from 6 million per year to 66 million. It comes as no surprise that television viewing was recorded as Britain's number one leisure pursuit. Analysis of children's viewing habits indicate that 11 - 12 year olds watch approximately 25 hours of television per week and 13,000 hours per year (Vieth 1980). This is confirmed by Kelly (1981) and broken down into 49% of boys and 39% of girls watching more than 4 hours of television per day. The vast amount of television viewing by children could be a source of general concern. In terms of the portrayal of science and scientists, a casual perusal of television programme listings shows many of the films available for viewing are either old films or modern science fiction, both types of which portray scientists as mad or evil or both.

In modern society where diseases and surgical techniques that were unthought of 10 years ago, have become commonplace, it is essential that the media portray the scientist carefully. Portrayal of the mad, evil scientist next to news reports of the latest outbreak of an incurable virus or new, ethically sensitive surgical technique, cannot do the scientist's image many favours.

Viewing habits have been linked to scientific attitudes generally. A survey of children's viewing habits of 27 specified programmes showed that children's viewing habits can be linked to age, social class and gender (Omerod 1989) . This is confirmed by Chambers(1983) and Kelly (1981). After controlling for the significant effects of social class, age and gender, Gibson and Francis (1993) found a positive relationship between the viewing of scientific current awareness programmes and a liking for science and a negative relationship between the viewing of soap operas and liking for science. They (Gibson and Francis 1993) suggested that this indicated that those adolescents who took an active interest in the real world

> *"perceive both television and science as a*
> *means of gaining greater insight into that world"*
>
> p 188

It is also suggested that those adolescents who prefer soap operas and reject science are seeking a means of escape from the real world. Both boys and girls who prefer to watch 'current awareness' and science programmes have a greater liking for science. Johnson(1987) found that boy's practical science learning was reinforced by watching relevant television programmes, more than girls. Boys reinforce their practical science learning more than girls by appropriate television viewing and also reading relevant books. Though girls tend to read earlier and more frequently than boys they read fewer books about science and technology (Johnson 1987). Conversely, Hadden and Johnstone (1982) felt that the influence of the mass media and science fiction were not prominent in the development of interest in science. Nevertheless, literature and the media represent the many informal avenues for science education and television must be one of the most powerful due to the amount that children watch. The portrayal of scientists in the wide variety of programmes in which they feature must have some influence on the formation of children's perceptions.

x) The Teachers

One significant factor in the formation of children's perception of science is their teacher. The physical science teachers in secondary schools tend to be male. This presents a role model for both boys and girls of scientists being male. Attempts by the GIST to provide an alternative role model, of a female scientist, particularly chosen to be the antithesis of the stereotypical male scientist, showed a small change of the gender perception of scientists. There are other factors concerning the role of science teachers which could have a significant effect on the pupils they teach.

Harvey(1985) maintains that teachers have a 'major role' to play in the formation of children's attitudes to science. This has been reiterated by Boylan et al (1992) who state,

> *" the significance of the gender of the science teacher as a role model of a scientist emerged as an important determinant in their[the children's] construction of what is rather than what ought to be"*
>
> p 471

This extends from whether the children like the teacher as a person and to the way the teachers present their lessons and treat the children. One of the problems faced by all teachers is that of the social climate. Teachers expect the children to conform to the social 'norms' of gender appropriate behaviour. This expectation prevails from Nursery schools and through the whole educational process. Interestingly in Russia, where there is no gender differentiation in schools in that girls and boys are expected, both by school and society, to perform equally in all subjects there is a much higher proportion of female scientists and engineers. This different system of values appears to free the girls from Western perceptions of appropriate female careers (Omerod and Duckworth 1975). Chambers (1983) noted that there was an equal emphasis on men and women in science in China. Thus any argument that there are innate differences in attitudes and predisposition to study science founders (Omerod 1975).

If teachers expect children to conform to gender stereotypes, it is likely that they will comply and therefore see themselves as gender differentiated. The gender based messages in a classroom are subtle and complex and both teachers and children have developed strategies for coping with them to a certain extent. Boys' confident and often disruptive behaviour in science lessons tends to attract more of the teacher's attention and this is important in the science laboratory, where co-operative tasks need to be completed. Teachers tend to reinforce gender differences by being very strict and aggressive with boys (Smail et al 1982). The conditions in the classroom are more likely to favour boys' social orientation and their preference to form large hierarchical groups than the girls' preference for small groups of two or three (Öhrn 1993). Teachers, both male and female, tend to be more responsive to the needs of boys (Stanworth 1990). Interactions between boys and teachers is more likely to be initiated by the teachers whereas girls are more likely to initiate interaction. This can make the girls feel devalued, and the toleration by teachers of any practices which devalue girls in the eyes of the pupils, particularly the girls, contributes to the maintenance of the status quo (Stanworth 1990, Abraham 1993). A double bind situation is created for the girls. If the girls speak out in the manner generally associated with boys they gain some respect from the boys at the expense of the approval of their own sex, whereas the quietest girls are likely to be despised by the boys. Girls have been noted to actively deploy 'female' behaviours, such as passivity and compliance to remain in favour with teachers, especially male teachers, in order to deflect aggressive interactions. Male teachers have been noted to treat female pupils differently, by being more gentle and responding to their femininity. This brings into focus the adolescents girls' need to define their femininity in terms of society's ideal of womanhood whilst being in direct conflict with the image of academic achievement and scientists (Smail et al 1983). In the case of boys' sex role expectations in adolescence are compatible with the image of scientists (Weinreich-Haste 1983).

The pupils also have views about their science teachers. Both boys and girls view male teachers as more competent, better informed and better disciplinarians, but both feel more at ease with a teacher of their own sex. There is possibly some validity to these ideas. Female science teachers, in the secondary sector of education will more commonly have studied biology at higher levels. In the primary sector there are likely to be women who have not studied science since the age of fifteen. The outcome of this is that teachers are not confident in their ability to teach science, particularly the physical sciences. The advent of the National Curriculum has redressed this problem to a large extent, by including substantial amounts of science learning in initial teacher training courses and providing in-service courses for current teachers. Nevertheless the amount of specialised scientific training undertaken by teachers is thought to have an effect on the effectiveness of the teachers (Mant and Summers 1993). Teachers who lack confidence in their own understanding of scientific principles may pass this on to the children they teach; in the case of girls, this may have the effect of reinforcing their current prejudices.

Chapter 3

Methodology

Introduction and Aims

The five original questions to be addressed by this study, namely ;

What are children's perceptions of scientists?

What are children's perceptions of science?

What are children's perceptions of science experiments?

Are these the same for boys and girls?

Is there a difference of perception in different types of schools?

were revealed from the literature to be very broad. A number of points emerged which were thought to be influential in the formation of children's perceptions. These are listed below;

ability

socio-economic background/occupation of parents(Chambers 1983)

ethnic background (Chambers 1983)

the gender of their teacher

the gender mix of their class (Kelly 1988)

the type of school (state/independent) (Dale 1975, Young and Fraser 1994)

the pupils' position in the family (Dean 1993) the pupils' viewing/reading habits (Schibeci 1986, Bassalla 1976)

the pupils' hobbies (Johnson 1987)

the pupils' attitudes to school(Kelly 1983)

It was necessary to take account of all these factors in the design of the instruments to be used in the study.

The research aimed to identify the children's perceptions in three areas:

1) perception of scientists

2) perception of science

3) perception of scientific activities.

These three areas were each to form a distinct phase of the activity. Built into each phase were probes relating to the elements that had arisen from the literature .

All aspects of the instruments had to be accessible to all the children taking part and maintain their interest in order that the session could be completed in a professional manner. All parts had to be completed by the children with minimum investigator or teacher input, due to the time factor imposed on the activity sessions. It was important that the children didn't feel that they were being tested for their knowledge of scientific facts, as this might have discouraged some of them from participating, and also that they saw the completion of the questionnaire and tasks as a valid exercise from which they would gain experience whilst at the same time feeling that they were usefully engaged.

The data collection was therefore designed to interest the children and provide them with stimulating science activities whilst at the same time collecting all the information required. It was divided into three phases that allowed the children activity periods interspersed with writing. The phases were designed to flow into each other and not be seen as distinct and separate by the children, so that they could follow the session through at their own pace. At the same time, the pace of their activity was monitored so that all the children could be encouraged to finish the whole session, for their own sense of achievement. The session was introduced in such a way that the children were under no misconceptions that the session was a test and that their ideas were being sought and all of these were equally valid and valuable. The session took the form of a drawing followed by a questionnaire, science tasks and response sheet for the tasks.

i) Perception of Scientists

There appears to be little doubt that there is a stereotypical image of a scientist and that this image is generally male. Children's perception of scientists would appear to reflect this stereotypical image. The extent to which the image is held and is influenced by other factors such as teachers, schools and the media is still open to some debate. As the image of the scientist is generally that of a man, the activities associated with being a scientist appear to be generally seen as male activities and consequently school science activities become designated male activities.

In order to make science equally accessible to all children, as required by the National Curriculum, it is important that we understand children's perceptions of science and scientists. If the stereotyped male image of the scientist exists at the primary level, an understanding of the effect of this perception on the children's attitudes could help reverse or reduce the effect.

A request to draw a scientist can be seen as a relatively informal introduction to an activity session and whilst there are criticisms of this approach, a drawing as a test item is relatively straightforward to administer. Drawing is an activity that most children enjoy and see as a non-threatening activity as it does not draw on reading, writing or comprehension skills. Therefore children are generally willing to participate and provide material.

Alternative methods for seeking children's ideas, such as interviews and questionnaires require a significant amount of time and investigator input. They may not be relevant for every enquiry. The quantity of information which is gained from such methods may provide a deeper understanding of the subjects ideas and the reasoning behind the ideas may be more than is required for a particular study. Therefore if a trend of ideas is required rather than an in-depth analysis a simple drawing is a more appropriate tool to use. The DAST was felt to be the most appropriate tool to use in this study.

ii) Perception of Science

Investigations of the children's perception of science needed their ideas to be collected on an individual basis, in order that they could be correlated with their individual perceptions of scientists. Perceptions of science include a wide range of ideas, from the science studied at school to science in general and its effects on the children personally and society in general. In order to investigate the children's perceptions a number of instruments were considered. Any method of collecting information from the children needed to be such that the children could work largely on their own with minimum adult input.

An in depth and accurate view of children's attitudes might been gained by using a recorded interview technique, such as the Interview About Instances Technique (Osbourne and Gilbert 1990). However, interview methods for younger children have been cited as not appropriate due to the children's lack of ability to or willingness to verbalise their ideas (Cirirelli et al 1971). This may not necessarily be the case but in any event individual interviews are a time consuming procedure. Group interviews with large numbers tend to minimise individual contributions.

The method used by Mead and Metraux (1957) and Weinreich-Haste (1981) of the completion of unfinished sentences in the form of short essays, would not have been appropriate for the anticipated range of abilities in the age group studied, because of the reading and writing skills involved, though this method again would have given a deeper insight into the children's perceptions.

Questionnaires are a useful technique for eliciting information and require little external input, as they can be completed individually. A group questionnaire, where the children are asked questions as a group to which they respond on pre-printed sheets could be appropriate for data collection but was not considered so in this case due to other elements of the activity session and the fact that it can be seen as too reminiscent of a test situation.

A questionnaire that could be completed on an individual basis seemed to be the most appropriate instrument to use in this study. Questions and statements which require a single response in the form of ticking or circling the most appropriate answer from a selection pre-stated answers. This can be achieved by a questionnaire using a Likert scale as a form of response.

A Likert scale is a useful tool for recording attitude responses on questionnaires, in that the respondent selects, from a number of alternatives, the most appropriate response for them. Phrases are normally used, e.g. like most/strongly agree, but for younger children a series of smiley faces has been used to stand in for phrases. The smiley faces lend the questionnaire an air of informality which may appeal more to children than the more formal phrases. Likert scales can be of an odd or even rating scale. Odd scales allow the respondent a 'don't know' option which enables them to respond in this way if they are unsure of their attitude to a given item. An even rating scale does not allow for this option and forces the respondent to opt for a response, even if they are unsure of their response. This may invalidate some responses in that they are not the true response the respondent could have made, which may genuinely be 'don't know'. On the other hand by forcing a response with an even rating scale, the respondent is obliged to consider the question and make a response. This ensures the question is read and the easier option of selecting the 'don't know' category is not permitted. This is probably a more productive option for a wide ability range of children. Though it has to be borne in mind that young children may not have formed clear attitudes (Cirirelli 1971, Harlen 1993). Careful phrasing of the questions should overcome this problem so that the children are responding to a statement rather than their attitude being sought. Again, the questions if phrased appropriately can be answered with a yes or no response. By grading the sizes of the yes's and no's the degree of agreement or disagreement can be indicated by the respondent. This allows a rating scale with four responses. In order to assess attitudes to science a self completion questionnaire was felt to be the most effective method of collecting the data.

Many studies do not publish the actual instruments that are used for data collection and of those that have been published, many appear to be too complex for the age of the children involved in this study. A questionnaire should be clear and unambiguous and this is even more the case for younger respondents. Responses to items in the questionnaire need to be clearly identifiable and the method of responding straightforward. The most straightforward way of achieving this is for the respondent to mark, by ticking or circling a response. Written answers to items may give a greater range of reasons for choice, and are usually associated with open ended questions, but the amount of writing required should be appropriate to the potential respondents. Identification of attitudes is more difficult to extract in an absolute form, from data written in response to an open ended question. The questions need to be within the reading abilities of the subjects who will be completing the questionnaire. If questions are too wordy and complex, they may be misinterpreted due to lack of understanding and the responses will consequently be inaccurate. Conversely if the language is too simplistic, the more able children will not find the activity interesting or useful and may respond inaccurately. This is particularly important for younger children. Therefore with younger children of a range of abilities, it is more appropriate to use clearly worded, unambiguous statements for which there is a tick or circling method of response. Ticking or circling a response also tends to minimise the potential for errors on the part of both the respondent and the researcher coding the data. The length of the questionnaire is important in that one that is too long will lose the interest of the respondent and the resulting responses may be absent or an inaccurate response may result as the respondent fails to reply to later items or replies in a random manner in order to finish and therefore comply with the activity. The layout and presentation of a questionnaire should look inviting and easy to complete, thus maximising the co-operation of the respondents (Cohen and Manion 1994, Morrison 1993).

Other items of information relating to the children's reading and television viewing preferences needed to be collected and this was thought to best achieved using a pre-selected list of items which the children could place in rank order. This was thought to be more preferable than allowing the children to list their preferences as this would have been open ended and may not encourage less able children to respond. A poll of favourite programmes and reading material was conducted with groups of children of similar ages who were not to be involved in the study and a list was compiled from this.

When seeking preferences from a selection of items a rank ordering system is a concise method. The subject is presented with a number of items and asked to order them according to their preferences.

Therefore of the items, say five, number one is the most preferred and number five is the least preferred. Difficulties may arise if there are two or more items equally preferred. Such items could be labelled with the same number but this increases coding and analysis difficulties. Therefore encouragement to make a decision between the equally preferred items is needed. This requires clear instructions before the subjects begin.

iii) Perception of Scientific Activities

Attitudes to activities can be assessed using interviews or response sheets. Interviews, though possibly yielding more of an insight into the reasoning behind a respondents attitude, need to be conducted on an individual basis. Interviews with small groups can be biased towards the more confident and voluble members. Individual interviews require an enormous amount of researcher input and are not appropriate for large groups of subjects.

Response sheets, using a rank ordering system allow individual responses to be made without influence from other subjects and are more likely to reflect individual subjects' attitudes. Practical science activities can be assessed in terms of the degree of success of completion of an experiment, in terms of a correct outcome. This relies heavily on the subjects' prior knowledge of science activities in terms of subject matter and skills of use of apparatus. Apparatus may differ slightly in different locations and this may affect the different groups of subjects competence in completing the exercise. If the practical science activities are presented in terms of an exploration rather than a defined experiment the anxiety about obtaining the correct answer for success should not be aroused and as such the activity becomes less threatening and open to all. If all the subjects use the same apparatus any discrepancies that may affect the activity are reduced.

Instrumentation

i) Perception of Scientists

The drawing the children were asked to produce was the 'Draw A Scientist Test (DAST) (Chambers 1983). Children have been observed to complete this activity within 15 minutes (O'Maoldomhnaigh and Hunt 1988) and this appears to be a reasonable time limit to allow for this study. Any child who has not finished in this time can be given the opportunity to finish at the end of the activities, if time allows.

This instrument has been used by several researchers looking at various aspects of children's perception of scientists (Tuckey 1992, Schibeci and Sorensen 1983, O'Maoldomhnaigh and Hunt 1988, Symington and Spurling 1990, O'Maoldomhnaigh and Ni Mhaolain 1990, Newton and Newton 1991, Hobden 1993, Preston 1995, Jannikos 1995). Though the focus of inquiry differed slightly among the studies the method of use was generally similar. The results from the above studies differed slightly but the general theme from all was that this test was a useful way of eliciting the children's ideas about scientists. The majority of the children in all the studies seemed willing to draw for the researchers and the resulting drawings showed a wealth of ideas and the quality indicated full participation. There have been a number of criticisms levelled at the DAST but it still continues to be used as a method of eliciting ideas about scientists and as such was felt to be valid in this study. The fact that the image presented is held at that moment in time has to be born in mind and ideally the study sample should be revisited to ascertain if the children's drawings change in any significant ways. This was not possible in this case due to lack of time.

The test was used in this study because it was felt that it would be easily administered to all the children involved, irrespective of their ability and communication skills. Children appear to enjoy drawing and generally accept it as a non threatening activity. This made it a good starting point for the rest of the activities that the children would be

asked to complete during the session. The instruction to 'draw a picture of a scientist' is given without guidance or instruction. The aim of this is for the children to draw their ideas without any influence or bias from the administrator. There is a possibility that the lack of guidance itself can influence what the children draw. Symington and Spurling (1990) suggest that without any guidance to draw on, children are likely to produce the public stereotype image of the scientist, rather than their own idea. This is a valid point but only goes to underline the fact that there is a public stereotype image of a scientist and if the children draw this, they themselves must therefore be influenced by it. Any child who could not start was asked to "do the best you can". The inability to produce a drawing has been suggested as indicating that the children have no idea of the image of a scientist, but is just as likely to be that some children have difficulty starting work on a clean piece of paper.

The instructions given to the children for the exercise, namely 'draw a picture of a scientist', has been questioned. The instruction has been said to be misleading in that it implies to the children that the person requesting the drawing wants them to draw for them and so they produce a drawing which they feel fits the requirements of that person (O'Maoldomhnaigh and Ni Mhaolin 1990 and Symington and Spurling 1990). O'Maoldomhnaigh and Ni Mhaolin (1990) changed the instructions to 'draw a picture of a man or a woman scientist'. The results revealed that a higher proportion of female scientists were drawn by girls in response to a second instruction. This, they suggest, is because girls defer drawing a female image until a male image has been presented, thus reflecting society's expectation that scientists are male. If this is the case then again the drawings produced are a reflection of the public stereotype held to be of enough importance by children to be reproduced on request.

Other alterations to the instructions were introduced by Symington and Spurling (1990). They were concerned that the instruction "draw a picture of a scientist" without 'guidance or purpose' was open to misinterpretation by the children. They initially requested a drawing from the children using the original instructions and then requested a second drawing using the instruction, "Do a drawing which tells me what you know about scientists and their work". They found that the majority of children drew two different pictures under the two sets of instructions. This should not be surprising as the two sets of instructions are quite clearly asking for different products. Symington and Spurling (1990) suggest that the less detailed drawings produced by the original instructions are a result of the lack of guidance given to the task. Without guidance the children are left to decide what is required by the request and opt for producing a picture which is recognisable as a scientist and therefore include elements which reflect their knowledge of the public stereotype of a scientist rather than their own interpretation of a scientist.

Again this is a valid point, but, if the children are aware of the public stereotype of the scientist and produce this when asked rather than their own personal interpretation, it shows a degree of tenacity for the stereotypical image. Thus if the children hold this image at all it must have some influence on their thinking, given that they do not naturally produce their alternative when given the opportunity. Thus, perhaps, the public stereotype image is perpetuated.

The validity of the test in probing the deeper understanding of the children's perception of scientists has been questioned. Schibeci and Sorenson (1983) suggest that it is a useful tool for gathering a 'global' image held by the students. Chambers himself suggested that the DAST was

> *"probably more useful in identifying rather than measuring attitudes"*
>
> Chambers 1983 p265

As this study was to compare the perceptions of scientist amongst groups of children from different educational backgrounds, the fact that the test was more likely to identify trends in attitudes was felt to be sufficient.

More complex and in depth methods for gathering information about the children's perception of scientists generally require a greater amount of administrator involvement. Boylan et al (1992) suggested that the DAST may not be valid because it only taps into a part of the children's understanding. It was not felt to be relevant instrument for this study, as an overall picture of the ideas of children in different schools was being sought in addition to other information. The time factor for the session was also a significant consideration.

Paper and pencil tests, of which there are several, are generally geared towards secondary age pupils. The results from this type of test allow a deeper understanding of the choices made by subjects due to the number and nature of the questions posed. This type of activity may not be suitable for younger children, who may view paper and pencil tests as threatening.

Despite the above short-comings and criticisms, the DAST was selected for use in this study. Several schools were to be visited over the period of the study and the ability range across the whole group was expected to be large and varied. The DAST is suitable for all ability levels because it requires no reading or writing skills. The information required from the drawing was essentially about the gender of the scientist among the different groups of children. The alterations to the instructions provided by O'Maoldomhnaigh and Ni Mhaolin (1990) were not considered suitable as this appears to be the only study that has used this instruction and the results were not hugely significant. In contrast, the majority of the other studies using the DAST have used the original instructions and would provide a basis for comparison, if necessary. The variation in instructions as provided by Symington and Spurling (1990) was not used because the main aim of the drawing was to find out the gender representation and their change would perhaps have altered this emphasis. Other parts of their study were directed more towards what the children thought scientists did. No specific request was made for captions or annotations on the drawings, but no remark was made if these appeared. There may well be a case for altering the instructions to the children when conducting this test, but it was not thought that this was an appropriate opportunity because of the emphasis of the rest of this study. The fact that the test is thought to assess a global image of the scientist and to ascertain the trend of attitudes was sufficient for this study's purposes.

ii) Perception of Science

The questionnaire (Appendix i) was adapted from the Science Attitude Questionnaire (Skurnik and Jeffs 1971). No other suitable alternatives for use with primary age children could be found at the time. Other alternatives that would give an insight into the children's perception of science were considered. The original tool used by Mead and Metraux (1957) which entailed finishing off sentences by writing a short essay, was thought to be inappropriate for the age group and the wide range of abilities anticipated in this study, though this technique does reveal a deeper insight into the ideas of the participants. It would also be relatively time consuming which was felt to be a disadvantage given the other elements of this inquiry.

The Interview About Instances (IAI) used by Boylan (1992) would have provided a deeper understanding into the reasons for the children's answers but was thought inappropriate due to the large number of children involved and the time limits for visits imposed by the majority of schools participating.

The Image of Science and Scientists Scale (Krajkovich and Smith 1982) was designed as an alternative instrument to interviews and essays, for use with younger children. It uses a 48 item Likert scale to assess attitudes. Unfortunately it was not available to the researcher.

The Science Attitudes Questionnaire (Skurnik and Jeffs 1971) was considered as an alternative. In its original form it was considered too long and complicated for the children in this study to maintain interest and concentration. It was also considered to be linguistically inappropriate, bearing in mind the anticipated ability range of children to be visited. As this was the only tool that was available to the researcher at the time, it was felt that an adaptation of the questionnaire would make a valid tool.

The original questionnaire consisted of 58 items. This was considered to be too many for the children to tackle effectively. Therefore the number of items was reduced. The original 58 items had been formed using collections of interviews with secondary age children. These items were then subjected to factor analysis and then field tested and reanalysed until the final 58 items had been identified. Five factors emerged for these items.

The adaptation of the questionnaire had to initially identify which of the original 58 items belonged to each factor. This was achieved using the administrators' manual, which gave details of the individual factors and examples of the items within each factor. The number of items was reduced to 24 items on this basis. A factor analysis was performed on the 24 items. This was to try and ensure that the nature of the questionnaire had not been altered radically from its original intention, that of measuring children's attitudes to science and scientists. Six factors emerged and are listed in Table 1.

Factor Number	Factor Name
1	Attitude to school
2	Attitude to school science
3	Like doing science
4	Dislike doing science
5	Attitude to scientists
6	Attitude to scientists

Table 1. Factors for Analysis

The response mechanism for the individual items was changed from a five point to a four point scale and the responses were changed from statements such as strongly agree/strongly disagree to different sized yes and no responses with different emphasis (see Appendix i). The not sure category of response was omitted to leave a four point response scale. The even rating Likert scale was a deliberate choice in order to force the children to make a response. There are problems with forcing a choice in that it may not truly reflect the actual response which might genuinely be a 'don't know', choice. Bearing this in mind, a response was felt to be desirable in that it gave opportunity for the children to think about the question.

Some of the statements that had been selected for inclusion in the adapted questionnaire were reworded to make their meaning more accessible to younger children, for example;

'Problems are being solved in science nowadays that will lead to a bettering of life of mankind.'

was changed to

' Science solves lots of problems for the world.'

The final selection of questions was then grouped randomly.

Some personal information was required from the children and this was combined with the 24 item questionnaire. The personal information was essentially, their age, their position in the family, their parents' occupations, reading preferences, television viewing and hobbies. The literature review had indicated that these aspects could have had some bearing on the formation of the children's perceptions. As only one visit per school was available as much information as was felt might be relevant had to be gathered during the single visit. No personal information that might have led to any child's identity being revealed was collected. No information about the children's ability was gathered. Discussion with the teachers involved and the headteachers of the schools prior to meeting the children had indicated that this was a sensitive area in some cases and so was not considered for any of the schools involved.

iii) Perception of Scientific Activities

The experiments that the children were asked to carry out were in the form of tasks (Appendix i). The tasks were chosen to represent gender aspects of science drawn from studies examined in the literature review (Ebbutt 1981, Johnson 1987, Robertson 1987, Erickson and Erickson 1984).

The limiting factors of the available locations had to be taken into account in the design of the tasks. The wide range of abilities had also to be taken into account. This study was conducted with the intention of finding out ways of helping children learning science and therefore none of the tasks could be too difficult or too easy. This could affect the children's perception of science activities. The time limit imposed on each session required that the tasks could be completed within the allotted time. The aim therefore was to design tasks which conformed to the gender specific ideas, were novel enough to hold all the children's interest but also in line with topics in the National Curriculum and could be seen as complimentary and/or reinforcing to the topics they were likely to have studied and could be satisfactorily completed in the time. This was felt to be important as the teachers were releasing their classes to participate in the study and the pressures on curriculum fulfilment can be exacting.

Physics is generally thought to be hard and a male orientated subject (Omerod 1981, Kelly 1981, Weinreich-Haste 1981) and electricity, in particular, is regarded as a male activity (Morgan 1989). Men tend to mend the electrical gadgets at home and the job of an electrician is seen as definitely masculine (Kelly 1982, Weinreich-Haste 1990, Morgan 1989). A simple electrical circuit was chosen as a 'male' experiment. In this task the children were required to construct a circuit using 2 wires, a bulb and a battery in a holder, to make the bulb light up the nose of a clown face they were given.

Biology and biological aspects of science are generally thought to be easier and more female activities (Omerod 1981, Kelly 1981, Weinreich- Haste 1981). A 'female' task would ideally involve biological aspects of science. Due to the physical limitations of the available rooms and the fact that all the equipment would have to be transported and also be robust enough to withstand handling by many children, biological experiments were thought to be inappropriate. Therefore an alternative 'female' experiment was required and the research suggested that colour experiments were viewed as having the aesthetic element of science which girls are said to find more acceptable.

The children were presented with three different coloured pieces of card, red, green and blue, and a piece of white card. They were asked to looked fixedly at one piece of coloured card for 30 seconds and then transfer their gaze to the white piece of card for 30 seconds and note down what they saw. The experiment deals with complementary colours which appear on the white piece of card and is the effect of temporary exhaustion of colour receptors in the retina.

Light and mirror experiments were seen from the literature to have a neutral orientation and so a simple experiment using mirrors was devised. This involved placing two mirrors at an angle to each other and a small figure in-between the mirrors. The children were then asked to count how many reflected figures they could see and to measure the distance between mirrors. There is a relationship between the number of reflections and the angle between the mirrors. It was not established whether all the children would be competent in the use of protractors for measuring the angle between the mirrors, so a linear measurement, using a tape measure, was substituted. Mirrors have been indicated as having a slightly female bias, particularly for older girls, but in general, light experiments are not mentioned as being perceived as gender biased. In an attempt to ensure neutrality, a Lego figure was used as the object for reflection. Boys are more likely to be familiar with Lego construction kits. If the children perceive the mirrors as being more appropriate for girls, the Lego figure may balance this perception.

The various instruments were piloted with a group of 20 children selected from one of the schools participating in the final study, but not in the study group and from one school not participating in the study. Alteration to the instructions, to make them more explicit was the only adaptation required.

The children were asked to complete the tasks and then fill in a response sheet. This asked them to rate the three tasks from 1 to 3 in order of how scientific they felt the tasks were, how much they had enjoyed doing them and how easy they felt the tasks were. They were also asked their preferences for partners as the possibility of mixed groups affecting their performance or enjoyment of science activities was indicated from the literature as possibly relevant.

The Sample

There were 289 children selected in Year 5 (age 9 - 10 years old) from 15 different schools, encompassing a large geographical area and a wide range of socio-economic and ethnic backgrounds. The schools ranged from a medium size urban state school to a small independent preparatory school. They were divided into four groups;

boys only independent

girls only independent

mixed independent schools

mixed state schools.

A preliminary visit was made to each participating school to ascertain which children would be available, the room available for use and the timing of the visit. The period designated for fieldwork coincided with the Statutory Assessment Tests (SATS) for Year 6 and thus it was decided to limit the study group to Year 5 children.

Discussion with staff during the visits indicated that enquiries into the children's abilities, ethnic origins and socio-economic backgrounds were sensitive issues, so these elements were not pursued. The assumption that the children would be of a wide range of abilities was therefore based on 15 years teaching experience in a wide variety of schools. A few schools specifically requested anonymity for the participating children and this was therefore assured for all children in all schools.

Procedure

Discussion with staff during the preliminary visits identified that the average length of a science lesson was one hour. Some schools had clear and concise time requirements for the visit and that was also one hour.

Science lessons at primary level, are not always held in science laboratories and there is a wide variation in the type, quantity and quality of equipment available. These factors had a bearing on the type of activities that the children could undertake. In the event all aspects of the study activities were designed to be completed in one hour. All the children used the same equipment which was taken in for each visit. This ensured that all the children had the same chance of success at all the tasks. All the equipment was checked as working and complete before each visit.

The majority of class teachers were, by their choice, not present during the activity session. The groups of children were asked to work in pairs as this was found to be the most common working format in their normal science lessons. Some of the pairs were those already in place. Where science activities were normally performed on an individual or group basis, the children were grouped in pairs for the activity session.

The session began with an introduction during which it was stressed that the session was not a test but that the children's individual ideas were being sought in order to find out about what children thought about science and how they felt about scientific activities so that teachers could make science lessons better for everybody.

The children were presented with all the pieces of paper they would require and packages of science equipment. Each child was given a sheet for their drawing, a questionnaire, a set of task instructions and a task response sheet. Each pair of children was given three packets of science task equipment. During this time the method for completion of the drawing, the questionnaire and the tasks was outlined and any questions arising were answered.

The children were then asked to draw a scientist, using the instruction "On this piece of paper draw a picture of a scientist". Any child who had difficulty starting was asked to "Do the best you can". In the event very few children had any difficulty producing a drawing. After 15 minutes, the children were asked to move on to the questionnaire which they were given another 15 minutes to complete. The method for responding to the statements was reiterated. Any problems, such as difficulty with reading the statements was dealt with. After 15 minutes the children were reminded to move on to the tasks.

The tasks used were written out with explicit instructions (Appendix i). This ensured that all the children initially had the same exposure to the same amount of information about the task. The activities had been outlined in the initial introduction. Any help that was needed was freely given, though no note was taken of which groups asked for help. Once the children had finished the tasks they were asked to fill in the response sheet.

When the children had finished all the required activities they generally wanted to explore the equipment further and this was an opportunity to discuss any questions and queries that had evolved from their work. Generally the children were very enthusiastic and wanted to know more about all the topics. This was an opportunity to talk to the children in groups and individually, though the discussions were not recorded in anyway.

In general the children completed all elements of the session in the time allowed and there was an opportunity to talk to the groups. Some of the children claimed to have finished when in fact they had not. Because of the large numbers involved in some classes it was not possible to check every response sheet before leaving the room. Therefore some of the task sheets were not completed appropriately. Some of the children found difficulty maintaining concentration throughout the length of the activity session. Though there is no possibility of justifying the conclusion that these children would probably have had difficulties in any session, experience suggests that this might be the case. In general the majority of the children participated willing and enthusiastically in all aspects of the session and the discussions that ensued indicated that their interest had been captivated and maintained.

Method of Analysis

The children's drawings were analysed according to the DAST seven point scale (Chapter 1 page 23) and allocated a gender, male, female or indeterminate. These were checked by an independent, person who was not a teacher and therefore unused to interpreting children's drawings.

The responses to the questionnaire and task activities were coded and entered on to the computer for statistical analysis. Initially descriptive statistics were produced to identify results which might merit detailed examination. Subsequently the Chi square test was used to investigate the probability of differences between groups being attributable to chance factors.

Chapter 4

Results

Introduction

The five original questions posed for this study (see page 12) were grouped into three elements of inquiry for the design of the instruments and analysis. The childrens' perception of scientists, of science and of science experiments were the three elements. These perceptions may be affected by the child's gender and type of school attended and these factors are common to all three elements.

The data were analysed using the SPSS computer software, initially to look for any trends, and then to analyse the comparative data. These analysise are outlined below. Discussion relevant to each element of enquiry follows each detailed analysis and is then summarised in total in the following chapter.

i) Perception of Scientists

Gender of Scientists

The drawings were examined for the gender of the picture drawn. Three categories were designated, male, female and indeterminate. The drawings were allocated to the indeterminate category when there were no obvious clues as to gender, such as clothes, hair style and beards. Some of the drawings in this category could also be classified as 'weird, magical or mythical'. The 'magical/mythical' drawings of scientists will be dealt with later as a separate issue. The results are presented in Table. 1.

Table 1. Gender of drawing of scientist: girls and boys.

Gender of Scientist	Number					
	girls N = 104		boys N = 135		all N = 239	
	No.	%	No.	%	No.	%
Male	67	64.4	118	87.4	185	77.4
Female	37	35.6	4	3.0	41	17.2
Indeterminate	0	0	13	9.6	13	5.4
Totals	104	100	135	100	239	100
	N = 239					

These results were checked by an independent person, who had no teaching experience but was trained as a scientist. There was 99% agreement on the interpretation of the drawings. Obviously the interpretation of the gender of the drawings was made in the absence of the children, but as there was good agreement between the two analyses of the drawings, the assumption that they had been correctly interpreted seems to be fair.

The children in this study appear to conform to the general opinion in their expression of a scientist as being male. The majority of children drew male scientists (77.4%). The drawings of female scientists (17.2%) were mainly drawn by girls. Only 3% of boys drew a female scientist. This is approximately in line with the findings from the studies reviewed, in that the majority of drawings of female scientists are by girls. The proportion of female scientists drawn generally, by both boys and girls, appears to be higher than in other studies. Certainly the proportion of female scientists drawn by girls is higher than any study reviewed. This may be significant to those reviewing the impact of the revised science curriculum and those pursuing equality of opportunity for women in the field of science. It may be worth reviewing the uptake of science by women when this cohort of Year 5 (9 - 10 years old) children are aged 21 years. The appearance of the indeterminate gender drawings seems to be the sole preserve of the boys, 9.6% of all the boys produced a non determinable drawing of a scientist (5.4% of all the children). This again conforms to the majority of findings examined in the literature, where the drawing of alternative scientists tends to be by boys. Some of the indeterminate drawings could be classified as mad/mythical alternatives, others just gave no obvious clues as to gender.

If the groups are then analysed in terms of the type of school attended it may be possible to see if there are any trends attributable to the different types of school. (Table 2)

School type	Gender of Drawing					
	male		female		indeterminate	
	No.	%	No.	%	No.	%
ind boys N = 59	52	88.1	2	3.4	5	8.5
ind girls N = 48	30	62.5	18	37.5	0	0
ind mixed N = 56	45	80.4	9	16	2	3.6
state mixed N = 76	59	77.6	12	15.8	5	6.6
N = 239						

Table 2. Gender of drawing of scientist - school type

There appears to be a difference in the proportion of male and female scientist drawings produced by children in different types of school. A Chi square analysis indicates that there is a high degree of significance ($p < 0.002$) attached to the type of school attended and the gender of the drawing produced. The girls only schools produced a relatively high proportion of drawings of female scientists compared to the mixed and state schools. In order to see how the proportion of drawings was distributed in the state and mixed schools, the schools were analysed separately for girls and boys responses (Table 3).

Table 3. Gender of drawings in mixed schools

School Type	Gender of Drawing					
	male		female		indeterminate	
	No.	%	No.	%	No.	%
ind mixed boys N = 32	28	87.5	2	6.25	2	6.25
ind mixed girls N = 24	17	70.8	7	29.2	0	0
state mixed boys N = 44	39	88.6	0	0	5	11.4
state mixed girls N = 32	20	62.5	12	37.5	0	0
N = 132						

It can be seen that the girls in the mixed schools drew a higher proportion of female scientists than the boys. The girls in mixed state schools drew an even higher proportion of male to female scientists than their female counterparts in mixed independent schools. The girls in mixed state schools drew 25% more male than female scientists, the girls in mixed independent schools drew 41.6% more male scientists, whereas the boys in mixed independent schools drew 81.25% more male than female scientists. The Chi squared analysis shows that there is a high degree of significance ($p < 0.001$) attached to the likelyhood of girls in mixed schools drawing a female scientist. This would seem to indicate that the girls are more likely than the boys to assume that a scientist could be female. It would also appear that the gender stereotyping previously seen is not as strongly held by girls in all types of school. There is a difference in the proportion of the girls drawing a female scientist in each type of school. The girls in the all girls schools drew the highest proportion of female scientists, followed by girls in state schools. Girls in mixed independent schools drew a lower proportion of female scientists than their counterparts in the girls independent schools and state schools.

The boys in all types of school appear to have a definite idea of the gender of the scientist as being represented by a drawing of a male. 87.4% of all boys drew a male scientist. In each group of boys, between 88.1% and 87.9%, drew pictures of male scientists. This tends to indicate that the type of school appears to have little effect on the boys' interpretation of the gender of the scientist, and that they generally regard the scientist as being male. Boys in state schools would seem to feel that a scientist cannot be female, as no drawings of female scientists were produced by any boy in a state school. The girls, on the other hand, drew generally fewer male scientists (64%) than the boys. The proportion of girls drawing male and female scientists in each type of school is represented in Table 4.

Table 4. Responses of girls in different types of schools

School type	Gender of Drawing					
	male		female		indeterminate	
	No.	%	No.	%	No.	%
ind girls N = 48	30	62.5	18	37.5	0	0
ind mixed girls N = 24	17	70.8	7	29.2	0	0
state mixed girls N = 32	20	62.5	12	37.5	0	0
N = 104						

There appears to be a difference in responses from girls in mixed state and independent single sex schools and girls in independent mixed schools. The drawings by girls in all single sex schools and girls in state schools both consisted of 37.5 % representations of female scientists, whilst 29.2% of girls in mixed independent schools produced drawings representing female scientists. The proportion of girls attending mixed independent schools, who drew male scientists, was 70.8%. The girls from single sex independent schools and mixed state schools produced the same proportions of male drawings (62.5%). Thus the girls in mixed independent schools appear more likely to expect that a scientist will be a man, whereas girls in single sex schools and state schools appear to be less convinced that a scientist will be a man. A Chi squared analysis indicates $p < 0.8$ indicating that the difference in the proportion of different types of drawing produced by girls in different types of schools is not significant.

The drawings produced by the girls show differences in gender specification according to the type of school, as seen above. Other factors which could be affecting these interpretations were sought. Firstly the gender of the science teacher was considered. The results were re-tabulated to take account of the school type and the gender of the teacher and are presented in Tables 5 and 6.

Table 5. School Type and Teacher Gender with Gender of Drawing (Male Teacher)

School type	male teacher							
	gender of drawing							
	male		female		indeterminate		total	
	No.	%	No.	%	No.	%	No.	%
boys ind N = 59	52	88.1	2	3.4	5	8.5	59	100
boys mix ind N = 22	20	90.9	2	9.1	0	0	22	100
girls mix ind N = 9	6	66.7	3	33.3	0	0	9	100
N = 90								

Table 6. School Type and Teacher Gender with Gender of Drawing (Female Teacher)

School type	female teacher							
	gender of drawing							
	male		female		indeterminate		Total	
	No.	%	No.	%	No.	%	No.	%
girls ind N = 48	30	62.5	18	37.5	0	0	48	100
ind mixed boys N = 10	8	80	0	0	2	20	10	100
ind mixed girls N = 15	11	73.3	4	26.7	0	0	15	100
mixed state boys N = 44	39	88.6	0	0	5	11.4	44	100
mixed state girls N = 32	20	62.5	12	37.5	0	0	32	100
N = 149								

In the study sample, all the science teachers in the boys' independent schools, were male and all the science teachers in the state schools and girls independent schools were female. Boys, in both boys' independent and state schools responded with a similar proportion of male drawings, indicating that the gender of the science teacher probably has little effect on the boys' perception of the scientist as male. The mixed independent schools had both male and female science teachers. Those children with a male science teacher responded by drawing more pictures of male scientists. The girls in mixed independent schools drew a higher proportion of male scientists when they had a female teacher. This is contrary to the result expected and has to be interpreted alongside other data, to look for other areas that could be affecting the girls representation of the gender of scientists. A Chi squared analysis showed that the gender of the teacher was highly significant ($p < 0.001$)

Girls in girls' independent schools, having exclusively female science teachers, drew a higher proportion of female scientists than any other group of either boys or girls. Nevertheless, the majority of the drawings produced by girls in all schools , were of male scientists. A general overview of the types of drawing produced depending on the gender of the teacher is represented in Table 7.

It is interesting that of the boys who have a female teacher, not one drew a picture of a female scientist. This would tend to indicate that the boys are not influenced by the role model of a female scientist and it may perhaps have a negative effect. Girls who have female science teachers drew a higher proportion of female scientists than their counter parts taught by men. This would indicate that the role model of a female science teacher may have a small positively significant effect on the girls.

Table 7. Drawing responses according to teacher gender, for total sample.

teacher gender	drawing gender						total
male teacher	male		female		indeterminate		
	No.	%	No.	%	No.	%	
boys	72	88.9	4	4.9	5	6.2	81
girls	6	66.7	3	33.7	0	0	9
female teacher							
boys	47	87	0	0	7	13	54
girls	61	64.2	34	35.8	0	0	95
					N = 239		

An overview of the the proportion of drawings and their type produced by boys and girls in mixed and single sex schools is reproduced in Table 8. These results would seem to indicate that overall there are relatively small differences in the proportion of girls drawing female scientist in each of the different types of school. At 32 - 37 % this is the highest proportion recorded for this type of research tool. The proportion of boys drawing female scientists remains more or less the same in that the majority of boys draw male scientists. The fact that a number of boys have drawn female scientists where it is reported that that are normally none, shows a slight increase on the findings from other research studies.

Table 8. Gender of drawing/school type.

Type of school	Gender drawing					
	male		female		indeterminate	
mixed school	No.	%	No.	%	No.	%
boys N = 76	67	88.2	2	2.6	7	9.2
girls N = 56	37	66.1	19	32.1	0	0
single-sex schools						
boys N = 59	51	86.4	2	3.4	6	10.2
girls N = 48	30	62.5	18	37.5	0	0

DAST Scores

The drawings were then analysed to obtain a DAST score. This score indicates the extent to which the children represent the 'standard' image of the scientists in their pictures. A score of 7 indicates they hold the 'standard' image and each score of less than 7 indicates the degree to which they have represented the standard image. If there are no indicators present the child can be said to have no 'standard' image perception of the scientist. The average DAST scores for all boys and all girls was calculated (Table 9).

Table 9. Mean DAST scores for all boys and all girls

	all boys	all girls
DAST score (mean)	2.1	2.1
N = 239		

The mean DAST score was the same for both boys and girls at 2.1. A score of 2.1 would indicate only a tenuous perception of the scientist. Yet the overall impression from looking at the drawings, is of a scientist in a laboratory coat at work on some scientific activity. Commonly the children did not include words or items of technology in their drawings. This immediately lowered their possible score. This score does not include the gender of the scientist in the drawing. This is a point of contention amongst researchers debating the validity of the DAST score in that the facial hair indicator immediately reduces the score of those children who have drawn female scientists. This could be countered by scoring the gender in with the indicators. If a score of 2 was given to drawings of female scientists and a score of 1 given to drawings of male scientists the facial hair indicator problem would be over come and this would then allow the DAST to be used to assess both the degree to which the standard image of the scientist was held in combination with the gender of the scientist, rather than as separate issues as they are at the present time.

The mean scores for girls and boys in the different types of school was calculated (Table 10). There are differences in the level of scores in the different types of schools. An ANOVA comparison of means indicates a significance of $p < 0.001$ indicating that the type of school attended is very significant in the formation of the children's perception of scientists in terms of their DAST score. Though the mean DAST score for all the boys and all the girls was the same, it appears that boys in mixed independent schools have a more clearly defined standard image of the scientist as defined by this test. Girls in both mixed independent and girls only schools scored higher than the mean of all boys. The lowest DAST scores were from the state sector schools, with both the boys and girls scoring lower than the mean. There are a number of possible reasons for the differences in scores between the independent schools and the state schools.

Chambers (1983) and Schibeci (1983) have both noted that children from higher socio-economic backgrounds achieved higher DAST scores. This they attributed to a greater awareness of the features of science and aspects that were likely to be involved in a job in the scientific field. An additional factor may be a greater experience of seeing scientists at work through the activities they are likely to participate in, such as a broader reading background and the general experiences which their parents expose them to. As independent schools in this country are exclusively fee paying, it is reasonable to assume that the children attending these schools are generally from higher socio-economic backgrounds than those attending state schools. The higher DAST scores seen in the children from independent schools supports Chambers' (1983) and Schibeci's (1983) findings of higher DAST scores in children of higher socio-economic backgrounds.

Table 10. Average DAST score and school type.

School Type	DAST score mean
boys ind N = 59	1.9
girls ind N = 48	2.1
boys mix ind N = 32	2.7
girls mix ind N = 24	2.3
boys state N = 44	1.6
girls state N = 32	1.7
N = 239	

Another factor may be the gender of the science teacher. The mean scores were compared with the gender of the science teacher to see if there was any effect apparent which might be attributable to the effect of the teacher (Table 11). If the children are taught by a male teacher and have an expectation that a scientists is male, they have their perceptions reinforced, thus producing a picture of a male scientist. This is the same for boys and girls. This cannot apply to the girls in girls' independent schools, who in this study had only been taught by female science teachers. It might be expected that the girls confronted with a role model of a female scientist may take that model as their role model, which would affect their perception of the gender of a scientist. Though the girls in all girls schools drew a higher proportion of female scientists than their counterparts in mixed schools the difference is not significant (see page 144).

Table 11. Mean DAST scores for different teachers.

		DAST Mean Scores	
school type		male teacher	female teacher
Boys ind	N=59	1.9	NA
Girls ind	N = 48	NA	2.1
Mixed ind boys	N = 32	3.0	1.7
Mixed ind girls	N= 24	2.0	3.3
state boys	N = 44	NA	1.6
state girls	N = 32	NA	1.7

Though there are individual differences across the different types of schools, there generally seems to be little significant effect of the gender of the teacher influencing the gender of the drawing produced by the children. An analysis of variance showed that there was no statistical significance between the scores for the children in different types of schools. This would indicate that the gender of the teacher has little effect on the children's DAST score.

In summary, most children in this study appear to think that the scientist is male, when asked to produce a drawing. Those children who drew female scientists were mainly girls. The fact that a few boys drew female scientists is probably not significant. What is of note is that a larger proportion of girls drew female scientists, than has been previously observed.

All the children in this study have a similar perception of the indicators which contribute to the 'standard' image of the scientist, though this seems to be rather low. Chambers (1983) and Schibeci (1983) suggested that by the age of 9 - 10 years old (Y5) there should be an average of 3.05 indicators per child. This study found that the average number of indicators was 2.1 per child. This may indicate that the 'standard' image of the scientist is less prevalent amongst this sample of Y5 (9 -10 year olds). This effect may be due to the advent of the National Curriculum and the efforts made to make science equally accessible to both boys and girls, and the many and varied efforts by a variety of bodies to open the world of science to the public. The children with the higher DAST scores appear to be those from higher socio-economic backgrounds, thus supporting Chambers (1983) and Schibeci (1983). As the DAST is derived from an intelligence test (Goodnough 1923), there is a possibility that the test is revealing differences in intelligence. The children in the independent schools, where the DAST scores were generally higher, may be revealing a higher level of measured intelligence than those children in state schools, where the DAST scores were generally lower, rather than a straightforward link with a socio-economic element. The issue of ability was not pursued in any of the schools as it was felt to be a sensitive issue by some of the participating staff, so there is no way of testing and validating this idea.

ii) Perception of Science

The 24 questions in the questionnaire were coded and subjected to a factor analysis. Those questions which did not fit the analysis were excluded from the final analysis. The final components are listed in their factor groupings in Table 12.

The responses were analysed for the six factors and a mean score for each response calculated. The mean ratings for each factor appear in Table 13. In addition to the four rating scores a fifth category was added for the purposes of analysis. Some of the children had ringed more than one answer, without making it clear which was their final response. The decision was made not to count either answer rather than to count both. The proportion of 'unanswered' questions was relatively small.

The responses to the questionnaire revealed that generally the children seemed to be reasonably enthusiastic about school (Factor 1) and also seemed reasonably enthusiastic about their science lessons (Factor 2)

The responses of girls and boys to the questionnaire were tabulated. These appear in Table 14.

A higher proportion of boys than girls appear to be negative about school, but the majority of children seem to be quite happy about their schools. The majority of both boys and girls seem to be reasonably happy with the science lessons at school, though they appear not to enjoy doing science outside of school. A higher proportion of girls than boys felt negatively about scientists and their work, but a majority of children indicated that they felt positively about scientists and their work.

The different types of school may affect the way the children feel about the different aspects examined in the questionnaire. The results for the different types of school are presented in Table 15.

Item	Loading	Communality
Factor 1		
Liking for school		
Eigenvalue: 6.937		
Percent of total variance: 28.9		
School is fun	.840	.739
I like my school	.849	.760
I enjoy school work	.779	.717
I like the teachers in this school	.756	.685
Factor 2		
liking for school science		
Eigenvalue: 2.307		
Percent of total variance: 9.6		
I enjoy science lessons more than any other lessons	.671	.632
I like my science teacher	.736	.648
I look forward to science lessons	.774	.741
I enjoy working for my science teacher	.665	.625
Factor 3		
positive about doing science		
Eigenvalue: 1.655		
Percent of total variance: 6.9		
I would like to work with people who make scientific discoveries	.800	.684
I do science experiments in my own time	.510	.480
My parents would like me to become a scientist	.621	.433
I should like to belong to a science club	.607	.641
Factor 4		
negative about doing science		
Eigenvalue: 1.410		
Percent of total variance: 5.9		
There are too many facts to learn in science	.587	.557
I do badly in science	.603	.525
I find science difficult to understand	.735	.645

Factor 5		
negative views about science		
Eigenvalue: 1.232		
Percent of total variance: 5.1		
Scientists are show offs	.554	.612
Science makes things which are a nuisance	.759	.647
Scientists waste public money	.555	.591
Factor 6		
positive views about science		
Eigenvalue: 1.009		
Percent of total variance: 4.2		
Science solves lots of problems for the world	.583	.562
I would much rather do experiments than read about them	.668	.539
I would much rather do experiments than listen to a lesson about the same thing	.760	.595

Table 12. Factors in the Questionnaire.

Factor	Response - %			N = 239		
	0 no answer	1 yes	2 a little	3 not much	4 no	mean score
1 liking for school	1.78	31.6	42.1	10.7	13.9	2.0
2 liking for science	1.1	32.13	37.5	16.8	12.6	2.1
3 positive about doing science	2.1	8.1	20.9	27.3	41.5	2.7
4 negative about doing science	1.5	22.3	37.8	26.1	12.3	2.2
5 negative about science	0.97	41.83	36.83	12.96	7.4	1.8
6 positive about science	1.7	70.8	20.2	3.1	4.2	1.3

Table 13. Mean responses to the Questionnaire

It is disappointing to find that the children are not enthusiastic about extra curricular scientific activities. A part of this may be due to the large range of other activities available to children outside school hours.

Mean Rating	Boys	Girls
Factor		
1	2.3	1.8
2	2.2	2.0
3	2.8	2.7
4	2.3	2.1
5	1.9	1.7
6	1.3	1.4

Table 14. Separate responses for girls and boys

Though there are individual differences in the proportion of responses to the different factorial elements, they generally follow the same pattern as the overall pattern of responses. This is confirmed statistically using a t-test ($p < 0.07$). The girls in girls only schools are very positive about school and both the boys and girls in the state school appear not to be very positive about school. The children in state schools seem to be more positive about doing science, whereas the children in the independent schools appear not to be as positive. The boys and girls from single sex schools are more positive about doing science in their spare time and the possibility of becoming scientists. The children in the other types of school appear to be less positive. Boys in mixed independent schools appear to think that science is reasonably easy and straightforward, whereas the boys and girls in state schools seem to feel that science is difficult. Girls in single sex schools and mixed independent schools appear to feel that science is only slightly difficult. All the children in all the schools feel very positively about scientific activities and scientists. Though there are a number of variations with respect to the different types of schools the effect of the gender of the science teacher may contribute to some of the differences. The responses were reordered in terms of the gender of the teacher.

	School Type		Mean Rating			
Factor	boys ind N = 59	girls ind N = 48	mix ind boys N = 32	mix ind girls N = 24	state boys N = 44	state girls N = 32
1	2.1	1.6	1.8	1.8	2.4	1.8
2	1.9	1.8	2.4	1.8	2.4	2.3
3	2.7	2.5	2.7	2.9	2.9	2.8
4	2.4	2.2	2.3	2.2	2.2	2.2
5	2.0	1.6	2.1	1.6	1.9	1.8
6	1.3	1.4	1.1	1.3	1.6	1.4

Table 15. Questionnaire analysis by school type

Table 16 shows the responses according to the gender of the teacher. There seems to be a slight difference in the pattern of responses. This difference is significant at a 5% level ($p < 0.02$). It would seem reasonable to assume that the gender of the teacher has an effect on the children's attitudes to science.

Factor	Male Teacher	Female Teacher
1	2.2	1.8
2	2.1	1.9
3	2.8	2.6
4	2.3	2.1
5	2.1	1.6
6	1.3	1.3

Table 16. Mean Responses for different teachers

iii) Perception of Scientific Activities

The experiments that the children were asked to carry out were designed to be of male, female and neutral orientations, based on information from the literature review and explained in detail in the previous chapter. The children were asked to score in rank order the experiment they thought was the most scientific, the easiest and which they enjoyed the most. Not all the children answered all of the questions in this part of the activity. The results are summarised in Tables 17 - 20 below.

Most scientific experiment					
Boys N = 118			Girls N = 97		
	No.	%		No.	%
electricity	87	73.7	electricity	67	69.1
colour	26	22.1	colour	21	21.6
light	5	4.2	light	9	9.3

Table 17. Analysis of how scientific the tasks were perceived.

Least Scientific experiment					
Boys N = 103			Girls N = 81		
	No.	%		No.	%
electricity	10	9.7	electricity	8	9.9
colour	42	40.8	colour	28	34.6
light	51	49.5	light	45	55.5

Table 18. Analysis of least scientific task.

Easiest experiment					
Boys N = 118			Girls N = 98		
	No.	%		No.	%
electricity	57	48.3	electricity	36	36.7
colour	43	36.4	colour	45	45.9
light	18	15.3	light	17	17.4

Table 19. Analysis of easiest task.

Experiment liked best					
Boys N = 121			Girls N = 98		
	No.	%		No.	%
electricity	77	63.6	electricity	33	33.7
colour	29	24	colour	53	54.1
light	15	12.4	light	12	12.2

Table 20. Analysis of most enjoyable task.

Not all the children answered the rank order questions for the experiments. In some cases this was because they had no time left, in other cases, mainly the boys in state schools, because they became engrossed in the experiments and failed to move on. Therefore the above numbers are for those children who answered.

Of the three experiments the children, both the boys and the girls regarded the electrical task as the most scientific ($p < 0.001$). A slightly higher proportion of boys than girls regarded the electrical task as being the easiest. A similar proportion of girls regarded the colour task as easier than did the boys ($p < 0.1$). The light task was regarded by both boys and girls as being the least scientific ($p < 0.1$). The boys generally liked the electrical task most of the three tasks and the girls liked the colour most of the three tasks ($p < 0.001$). The light task was regarded equally by both boys and girls as not liked best. It is interesting to note that the experiment that boys liked the best was also the one they rated as most scientific and easiest.

These results conform with the findings in the literature review. Electricity is still seen by boys as easier and more scientific than other topics. The girls responded to the colour task more favourably than the other tasks. The effect of the type of school and the gender of the children's teacher are summarised in Tables 21 and 22. There is very little difference between the responses of the children with a male teacher and those with a female teacher to the idea of which task was the most scientific.

The children found the question about their parents' employment very difficult to answer. Many of the children had no idea of the jobs their parents did. It was decided that there were so few intelligible results that this section of the questionnaire could not be sensibly analysed.

	Task	
School Type	Most Scientific- Electricity	Easiest
boys ind N = 59	67.8%	Electricity 49.2%
girls ind N = 48	60.4%	Colour and Electricity 43.8%
mixed ind boy N= 32	84.4%	Colour 50%
mixed ind girl N= 24	75%	Colour 50%
state boys N= 44	45.5%	Electricity 36.4%
state girls N = 32	62.5%	Colour 37.5%

Table 21. Task Preferences by School Type.

Male Teacher	
	Task
Boys N = 81	Electricity 71.6%
Girls N = 54	Electricity 66.7%
Female Teacher	
Boys N= 54	Electricity 53.7%
Girls N = 95	Electricity 64.2%

Table 22. Task Preferences by Member of Staff.

The children's viewing habits are summarised in Table 23.

There is a marked difference in the children's viewing habits. The boys prefer to watch sport, followed by cartoons and then comedy show. The girls preferred soaps, followed by wildlife programmes and then cartoons. Programmes with a scientific element of both fictional and fact were rated least watched by all the children. Boys are more likely to watch science fiction programmes, such as Star Trek, than the girls, though this programme does not rate very highly on their preferences. In order to see if the programmes that the children are watching have any influence on the formation of their ideas about scientists a deeper analysis of the content of the programmes that they enjoy watching needs to be undertaken. On the evidence from the data here, it would seem that scientific programmes whether of a fictional or factual nature are probably not influencing the children's perception of science simply because they do not watch many programmes with a scientific content. The assertion by Gibson and Francis (1993) that watching television soap programmes can be linked with a disincentive for science, often indulged in by girls, seems not to be upheld by the results. In the light of the fact that the girls in this study are reasonably positive about science, there is a possibility that the reasoning behind Gibson and Francis' statement is no longer valid. It is certain that the quantity and content of soap programmes is vast and varied and caters for many different viewpoints, but their main thrust is ongoing sagas of daily life amongst fictional communities. This aspect may be appealing to the girls, who are said to find the aesthetic and social elements of science of greater appeal than the more mechanical aspects. Further research into the type and content of the individual soap programmes watched needs to be conducted to investigate this further.

	Boys N=135	Girls N = 104
Programme	Ranked 1 - %	Ranked 1- %
Cartoons	15.6	8.7
Sport	34.8	3.8
Dr. Who	1.5	1
Wildlife	8.1	10.6
Star Trek	5.2	1.9
Quiz Shows	0.7	4.8
Films	9.6	7.7
Soaps	9.6	54.8
Tomorrow's World	2.2	1.9
Comedy Shows	10.4	6.7

Table 23. Television viewing preferences.

The children's reading preferences were collated and are presented in Table 24.

	Boys N = 135	Girls N = 104
Books	Ranked 1 - %	Ranked 1 - %
Animal Stories	8.1	24
War Stories	8.1	1
Mystery/Thrillers	25.2	32.7
Adventure Stories	26.7	24
Information books	1.5	1
Science Fiction	7.4	1.9
Comics	15.6	10.6

Table 24. Reading Preferences

The reading preferences of the girls and boys differ slightly, with the boys preferring adventure stories over mystery and thriller stories. The girls' preferences were in reverse, mystery and thriller stories over adventure stories. The main differences in reading preferences were in the girls' preference for animal stories, which were rated equal second overall, along with adventure stories. The boys generally appear not to be as keen on animal stories. Boys appear to read more comics than the girls.

Though science fiction was ranked 5th overall by both boys and girls, boys appear to read more of this type of book than girls. Disappointingly, information books were rated least likely to be read by all children.

The subject preferences of the children are recorded in Tables 25 and 26. Both boys and girls rate Games as their best subject, though boys in a much greater proportion than girls. This is in line with the findings from the literature review, particularly for the boys. Boys enjoy Maths, then Science. The girls second preference was Art, in almost the same proportion as those who rated Games as their first preference. Science came sixth in the girls' overall preferences, below Maths, History and Reading. This seems at odds with the previous results which would tend to indicate that the girls generally feel positive about science. In reality this could be interpreted as showing that whilst the girls are reasonably positive about science in general, given the choice they actually prefer other subjects for study.

Table 25. Subject preferences.

	Boys N = 135	Girls N = 104
Subject	Ranked 1 - %	Ranked 1 - %
Maths	12.6	12.5
Games	52.6	28.8
History	2.2	11.5
Science	8.1	5.8
English	4.4	4.8
Reading	0.7	7.7
Art	5.2	25.0
French	1.5 (ranked 2)	1.9
Geography	0.7	1.0
Music	0.7	1.0

Table 26. School subjects in order of preference

	Boys Preferences	Girls Preferences
Subject Order	Games	Games
	Maths	Art
	Science	Maths
	Art	History
	English	Reading
	History	Science
	Geography	English
	Reading	French
	Music	Geography
	French	Music

Chapter 5

Discussion, Conclusions and Implications for Further Research

It is apparent that there is a stereotypical image of a scientist, as being a man and that this is held by the children in the study. The degree to which their ideas conform to the 'standard' image as defined by Chambers (1983) and Schibeci (1986) appears to be tenuous if taken in terms of the average DAST score. This score is affected by the type of school that the children attend, in terms of the gender mix of their classes and the gender of their teacher. The effect of the gender of the teacher is not as straightforward a relationship as would be expected. Girls are affected more than boys by the gender of their teacher, in that girls from all the girls school and state schools who were taught science exclusively by female teachers showed in greater numbers than seen in any other study reviewed, that they see a scientist as female. There are other factors that may be affecting this change in emphasis, notably changes in society's attitude to women in general. Children at primary level appear to have a relatively clear view of who a scientist is likely to be, though the overall picture of scientists would seem to have remained unchanged since Mead and Metraux (1957) and Weinriech-Haste (1986) conducted their studies. In reality it is slightly different. The proportion representing the scientist as male, though forming a majority, was lower in this study than any of those reviewed in the literature, indicating, perhaps, a move away from a strongly held stereotypical view, at least so in the case of girls.

As this study is one of few that has looked at childrens' perceptions of science and scientists post National Curriculum, it would be easy to assume that the shift in the children's' perceptions is due entirely to the effect of equal access to all aspects of science as encouraged and promoted by the new curriculum. The reality is probably not so straightforward.

The shift in perception is only slight and seen mainly in girls' perceptions, though there is a very slight movement in boys' perceptions. Boys in boys' independent schools maintain the long held belief that the scientists are men. This view may be being reinforced by their male science teachers and the absence of girls from their classrooms.

Boys in boys independent schools and mixed state schools had similar DAST scores, 1.9 and 1.6 respectively and a similar proportion of male scientists (88.9% and 87%). They also drew a higher proportion of mad scientists than their peers in mixed independent schools. These boys also read more comics and watch more cartoons. It is possible that exposure to the caricature representation of a scientist via these media is influencing their perceptions.

The fact that the average DAST scores were low in all schools could also indicate that there is a move away from the firmly held stereotypical view of a scientists. Given the nature of the DAST and the criticisms levelled against its use it is perhaps not appropriate to draw such conclusions. The DAST proved useful in assessing the general trend in the children's perception of whether a scientist was male or female and any other conclusions as to the depth and tenacity of the image may be overstating the case. On the other hand the low DAST scores may also indicate that the public image of a scientist is being adapted by the children, who, using their experiences, are beginning to refute the stereotype.

Children's perception of science was found to be similar to that in the studies reviewed. The children are generally positive about science itself, though the enthusiasm is perhaps not as great as for other subjects such as art and games. The children on the other hand do not seem to be very positive about doing science experiments. This is not what would be expected from the studies reviewed, which generally indicated that children enjoy practical activities. Perhaps the advent of the National Curriculum and Sc1 in particular have altered the emphasis of scientific activities for the children in an inappropriate direction. Teachers may be having difficulties delivering scientific activities in a way children can enjoy under the prescriptive guidelines of Sc1.

The children most positive about school are also most positive about all aspects of science in school. This was expected from the studies reviewed. Boys in independent schools and all the girls are more positive about school than other groups of boys. Boys but not girls in state schools, though reasonably positive about school, are not very positive about school science, nor about doing science.

Children's interpretation of science activities reveals that electricity is thought to be a scientific activity and light the least scientific, by boys and girls equally. Boys felt that the electricity experiment was the easiest of the three and liked it best. Girls felt that the colour experiment was the easiest and liked it best. This is in complete accordance with the findings from the literature and so it could be said that the children's preferences for particular aspects of science do not appear to have changed. As preferences for particular aspects of science are thought to be linked to social and psychological aspects of children's' development, the fact that there is little change in their preferences should not be too surprising. The gender of the children's teacher did not appear to have any effect on the these preferences. The type of school that the children attended did not have any effect on the experiment that the children thought most scientific, but girls from girls' independent schools found the colour and light experiments equally 'easy'. This may indicate a difference in attitude to science experiments in the absence of boys. This again cannot be seen as unexpected. Indications from the literature review suggest that girls may be intimidated by the presence of boys and that boys tend to dominate equipment. This then is a clear indication that, in that absence of boys, girls feel free to use and become familiar and confident with equipment normally associated with boys activities. This in turn appears to increase their confidence to the extent that they find simple electrical tasks easy.

The children's viewing habits conform to what is expected from the literature, the girls being overwhelmingly partial to the soap opera type of programme followed by wild life programmes. The boys enjoy watching sport followed by cartoons and comedy shows. This might explain the appearance of the weird scientists being the sole preserve of boys as cartoons and comedy shows are those most likely to portray scientists from an alternative perspective. The efforts by television companies to interest children in factual science programmes seem not to be effective at the moment, as very few children claimed to watch Tomorrow's World or any other factual science programme. The link between the liking for 'soap operas' and dislike for science does not appear to be upheld by the girls in this study. Perhaps the sheer quantity of soap opera type television programmes in the present television schedules and the greater emphasis of equal access to science via the National Curriculum, is working to erode this factor. An alternative interpretation could be that the girls are viewing these programmes rather like cartoons or in terms of the personalities appearing in them, rather than becoming too involved in the content.

Informal discussion with the children during the sessions revealed that many children do not view Natural History, Veterinary Science and studies involving animals as science, though when pressed they were unable to provide an alternative classification. Wildlife programmes are popular with the girls though they do not view these programmes as scientific.

Children's reading habits showed a distinct lack of interest in reading of information books. This may not be as serious as might appear at first as the situation first seems as there is an enormous amount of information available via the computer to which many children have access, via school, libraries and at home.

This study suggests that the children's perception of scientists is changing. This could be the influence of the National Curriculum. The children's perception of science and interest in science is more or less the same as that suggested from previous studies. The major change in the childrens' perceptions appears to be in their perception of practical science activities. It would appear from the results of this study that the children are not as interested in practical activities as previously thought. The reasons for this are not clear. Again the influence of the National Curriculum could be important.

The childrens' hobbies were not analysed in any detail. This was mainly due to the diverse nature of the activities they reported as hobbies and the degree of parental involvement. The majority of activities that were reported as hobbies were organised and group activities such as dancing lessons, football, swimming lessons and judo. This would appear to be following the trend for today's children in that they have very little 'free' time. Their out of school activities are controlled by their parents to a large extent and the children are dependent on their parents to take them to their activities. Formerly the children's free time would have involved 'playing' in groups or alone, in an unstructured way, without overt adult supervision. Unstructured play is a time when the children are able to experiment with and test the skills they have acquired by experience, whether their play is physical or with materials. 'Free' time for today's children is more likely to be spent infront of a screen, either television or computer. Therefore neither girls nor boys are experiencing the 'tinkering' activities which have been cited as providing a useful background for scientific activities.

The influence of the type of school that the children attend is marginal except in the case of all girls independent schools, where there seem to be some advantages in terms of the children's perception of science and scientists being more positive than in other types of school. Boys in single sex independent schools seem to be strongly upholding the former perceptions of science and scientists. Independent schools are not legally required to to omplement the National Curriculum. It is possible that boys independent schools which have developed their own curriculum which is seen to be successful, in terms of the results achieved by the boys, see no reason to change their formula. If this is the case, the more formal teaching of subjects, science in particular, may be upholding and perhaps reinforcing long held beliefs about science and scientists.

The gender of the children's teacher may also be influencing perceptions to some extent. This can be seen by the fact that boys in all boys' schools with male science teachers are clear about scientists being male. Girls in all girls schools with female science teachers are almost equally clear that a scientists can be female. Children in mixed classes with teachers of different genders are more likely to adapt their view point with the exception of boys in state schools with female science teachers.

One of the main changes to children's education has been the introduction of the National Curriculum. It would be expected, with a reasonably large amount of science being studied by all children, that those with a negative perceptions might be reduced in the light of a broad and balanced study of science. This appears to be happening to some extent as far as girls are concerned in that more are indicating that they feel that a scientist can be female.

There are shifts in the childrens' perceptions of science, scientists and scientific activities. Not all the shifts in perception are towards the positive end of the spectrum. It is encouraging to observe that girls feel that science is no longer the sole preserve of men. This may have an effect on the children's selection of subjects to study at GCSE, 'A' level and further education. It would be interesting to monitor this cohort of children as they pass into secondary education and beyond to see whether the shift in perception is maintained.

Other aspects of science, which do not seem to be perceived in such a positive light, need further investigation to ascertain which factors are having an influence on the children's perception. The manner in which practical activities are introduced and conducted could be affecting the children's perception of practical activities. This needs further consideration. The types of scientific activities that are undertaken still appear to hold their gender specific identities, in the main, though girls in girls' only independent schools appear to be positive about scientific investigations. This could be an effect of the type of teaching to which they are exposed. Enquiries into the scientific qualifications of the teachers in the study was seen, in some cases, as a sensitive issue, therefore this aspect was not pursued. This is an area revealed by the literature review to be of note. Teachers with little experience of studying science are less confident about delivering science lessons. In the case of female teachers, many have not studied physical science or chemistry since the age of fifteen. Those female teachers who select to teach science are more likely to have studied science to a higher level and are therefore more likely to be more confident in their ability to teach all aspects of science. Since the inception of the National Curriculum, teacher training courses have had to address the issue of prospective teachers' relative lack of scientific knowledge. Therefore, newly qualified teachers should be entering the profession armed with the necessary competence and confidence to deliver science lessons. This area would benefit from further research to assess the new teachers confidence in teaching science and the impact this may have on the perceptions of the children they teach.

There is a difference in perception of science and scientist by girls in different types of schools. This study looked at girls in girls only schools who were taught science by female teachers. This was a feature of the schools to which access was permitted and not actively selected to be the case. An interesting comparison would be to assess the perception of girls in single sex schools who are taught science by male teachers.

The amount and content of television that children watch as both programmes and videos and the content of computer games may be influencing children's perception of science and scientists by the portrayal of caricatures and 'stereotypical' scientists. As children have a relatively large exposure to such media it could be having a greater influence on the formation of perceptions than previously thought. There is a difference in the types of programmes that the children choose to watch. The tenacity of the boys perception of the 'stereotypical' and 'mad' scientist could be being encouraged by the content of the types of programme they select. Analysis of the types and contents of the programmes chosen by boys and girls would give a clearer picture of this effect.

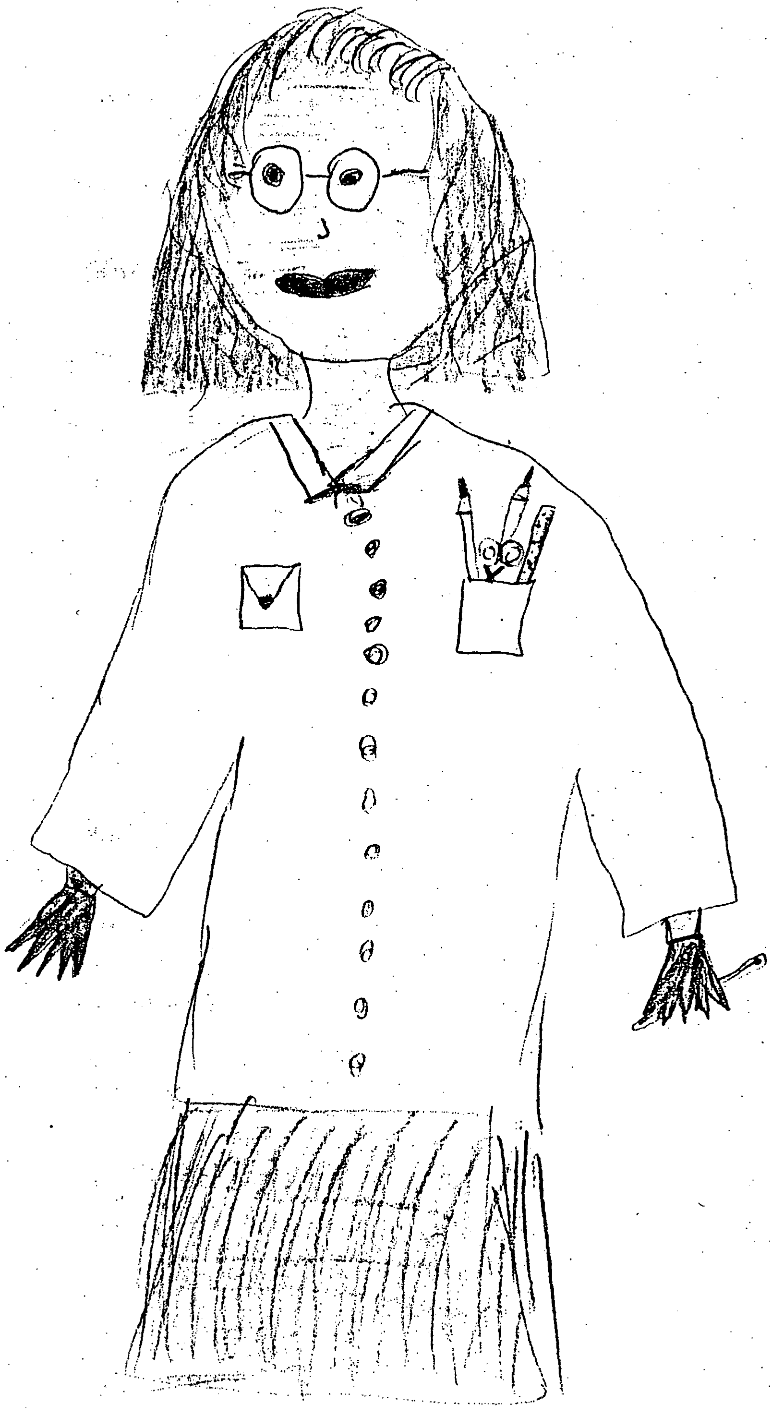
Overall it is encouraging to see a positive shift in the childrens' perception of science and scientists, even though the shift is small in some cases. It is discouraging to find that the children in this study are less positive about scientitic activities than has been previously found. The numerous factors that may be influencing this negative shift in perception would bear further investigation, to ascertain the extent of the effects and to suggest ways in which the balance could be redressed.

APPENDICES

APPENDIX I

CHILDREN'S DRAWINGS

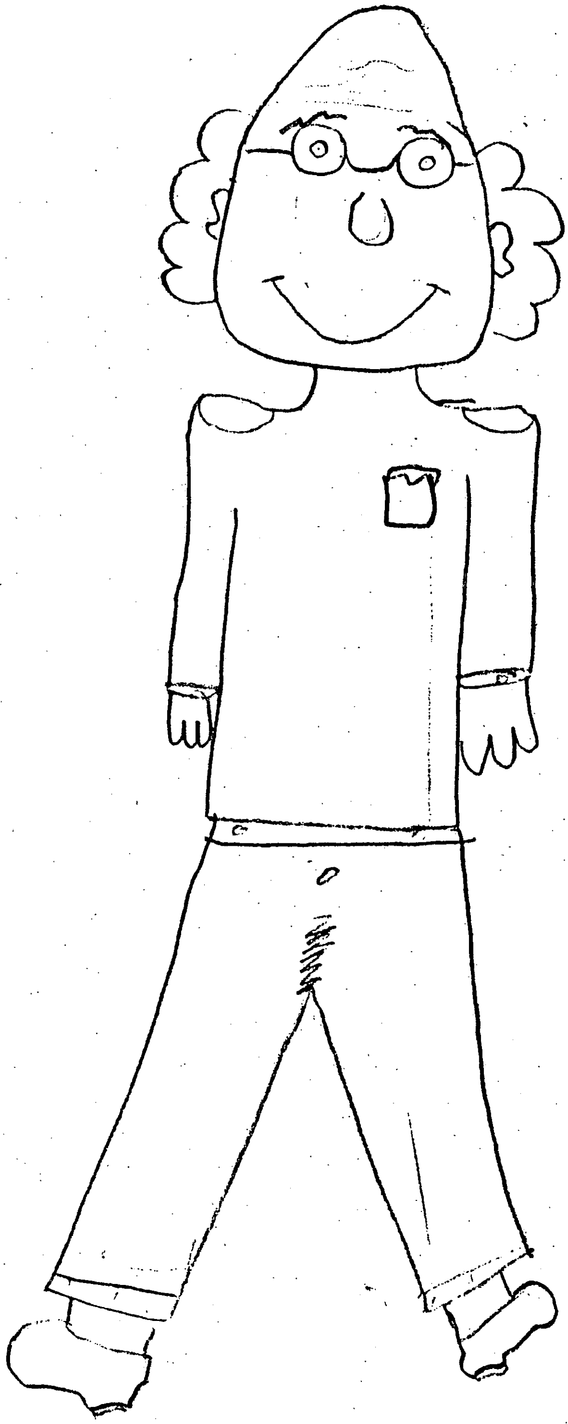
A Scientist



I am   a boy   a girl

In my class there are   all boys   all girls   boys and girls

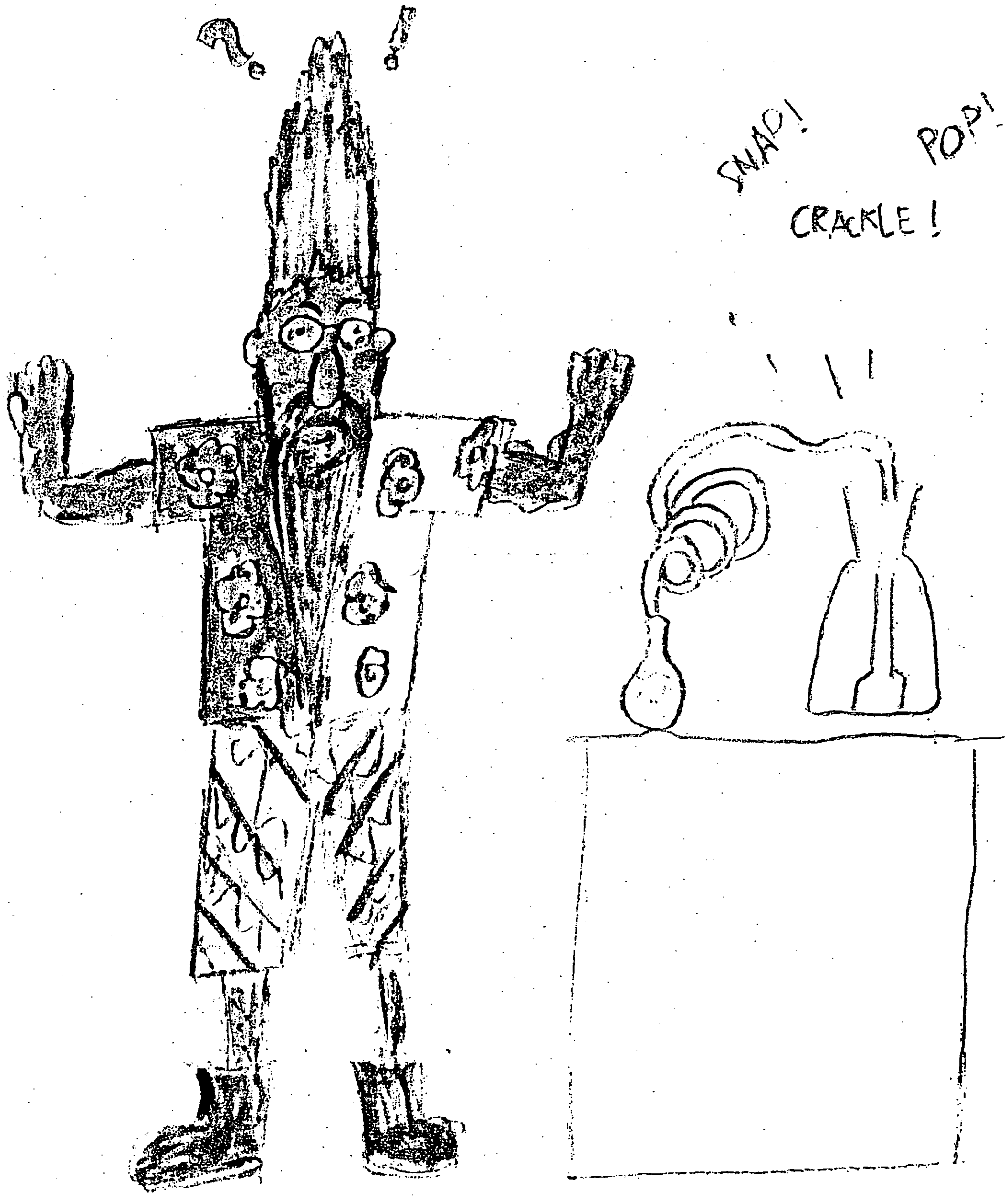
A Scientist



I am   *~~a boy~~*   *a girl*

In my class there are   *~~all boys~~*   *~~all girls~~*   *boys and girls*

A Scientist



I am ***a boy*** ~~***a girl***~~

In my class there are ***all boys*** [redacted] [redacted]

APPENDIX II

THE INSTRUMENTS

Answer these by ringing the one that is most like the way you feel.

I enjoy science lessons more than any other lessons.	*YES*	*yes*	*no*	*NO*
There are too many facts to learn in science.	*YES*	*yes*	*no*	*NO*
Science makes our lives better.	*YES*	*yes*	*no*	*NO*
I like my science teacher.	*YES*	*yes*	*no*	*NO*
Scientists are "show offs".	*YES*	*yes*	*no*	*NO*
I would like to work with people who make scientific discoveries.	*YES*	*yes*	*no*	*NO*
Science solves lots of problems for the world.	*YES*	*yes*	*no*	*NO*
School is fun.	*YES*	*yes*	*no*	*NO*
I do badly in science.	*YES*	*yes*	*no*	*NO*
I like my school.	*YES*	*yes*	*no*	*NO*
I enjoy school work.	*YES*	*yes*	*no*	*NO*
I do science experiments in my spare time.	*YES*	*yes*	*no*	*NO*
Scientist make things which are a nuisance.	*YES*	*yes*	*no*	*NO*
I find science difficult to understand.	*YES*	*yes*	*no*	*NO*
I would much rather do experiments than read about them.	*YES*	*yes*	*no*	*NO*
Scientists waste public money.	*YES*	*yes*	*no*	*NO*
I like the teachers in this school.	*YES*	*yes*	*no*	*NO*
My parents would like me to become a scientist.	*YES*	*yes*	*no*	*NO*
I look forward to science lessons.	*YES*	*yes*	*no*	*NO*

School is boring. *YES yes no NO*

I would rather do an experiment than listen to a lesson about the same thing. *YES yes no NO*

I enjoy working for my science teacher. *YES yes no NO*

I would enjoy school more if there were no science lessons. *YES yes no NO*

I should like to belong (or like belonging) to a science club. *YES yes no NO*

Which television programmes do you watch? Write 1 for the programmes you watch most, 2 then 3. If you don't watch the programme at all write 0.

	order
Cartoons	
Sport	
Dr. Who	
Wildlife Documentaries	
Star Trek	
Quiz Shows	
Films	
Soaps (like Neighbours)	
Tomorrow's World	
Comedy Shows	
Any others?	

What sort of books do you read? Write 1 if you read this type of book most, then 2 then 3. If you don't read that type of book write 0.

	order
Animal Stories	
War Stories	
Mystery/Thrillers	
Adventure Stories	
Information books	
Science Fiction	
Comics	
Any Others?	

What are your hobbies?

A Scientist

I am ***a boy*** ***a girl***

Who else is in your class? ***all boys*** ***all girls*** ***boys and girls***

Some Questions for you to answer

Are you a boy girl ?

How old are you?

Do you have any brothers(B) or sisters(S)? Write B or S to show whether they are older or younger than you. If there is just you, draw a ring round me.

oldest __ __ __ __ ME __ __ __ __youngest

Who is your normal science teacher a man a woman ?

Who else is in your class?
just boys just girls boys and girls

Which are your favourite subjects at school? Write 1 for your favourite subject, 2 for the next favourite, 3 for the next, all the way to 10 which will be your worst subject. If you don't have that subject put a 0.

	order
Maths	
Games	
History	
Science	
English	
Reading	
Art	
French	
Geography	
Music	

What job would you like to do when you leave school?

What do your parents do for their jobs? If you don't know what they do, write don't know.

Mum

Dad

Electrical Excitement

You will need:

2 wires with crocodile clips,
a battery and holder
a bulb in a holder
a drawing of a clown's face

Use the wires, battery and bulb in its holder, to make a circuit that will light up the bulb. Now use this circuit to light up the nose of the clown on the drawing you have been given.

Remember that for electricity to make things work, everything must be connected together so that the electricity can flow all the way round. If you get stuck someone will help you.

Now draw the circuit that you used.

Can you work out a way to make the clown's nose flash? How did you do it?

Colour Contrasts

Colours of things are not always what they seem. We can fool our eyes into seeing colours that are not really there.

You will need: 4 squares of coloured card
a square of white paper

Choose one piece of coloured card and lay it on the table on front of you. Place the square of white paper next to the card. Stare at the centre of the card whilst you count to 30. Now look at the centre of the white paper. Count to 20. What can you see? Write it down on the chart.

Now do the same with the other pieces of card. Make sure you write what you see into the chart.

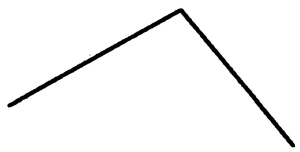
Original colour	***colour on white paper after 20***

Reflective Repeats

***You will need:** 2 mirrors*
2 holders
a lego man
and a tape measure

Have you ever stood in a lift that has mirrors all round and tried to see yourself both back and front? In fact that is very hard to do, but what you do see is lots and lots of reflections. You are going to look at the way two mirrors reflect each others images.

Set up the mirrors so that they look something like this



and put the lego man in between them.
Now look into the mirrors and count how many reflections you can see. Write this number in the chart. Now measure how far apart the mirrors are and write this measurement in the chart. Move the mirrors, either apart or together and repeat. Do this until you have 5 measurements in your chart.

	Number of Lego man reflections	*Distance between the mirrors (cm)*
1		
2		
3		
4		
5		

Which task did you like the best? Write 1 for the one you liked best, then 2, then 3 for the one you liked least.

order

Colour Contrasts
Reflective Repeats
Electrical Excitement

What did you like about it?

Which task did you find the easiest? Write 1 for the one you found easiest, then 2, then 3 for the one you found hardest.

order

Colour Contrasts
Reflective Repeats
Electrical Excitement

What didn't you like about the tasks? If there was nothing you didn't like, write nothing.

Which of the tasks is the most "scientific"?

order

Colour Contrast
Reflective Repeats
Electrical Excitement

Have you done any of the tasks before? If you have, tick which one(s).

Colour Contrasts
Reflective Repeats
Electrical Excitement

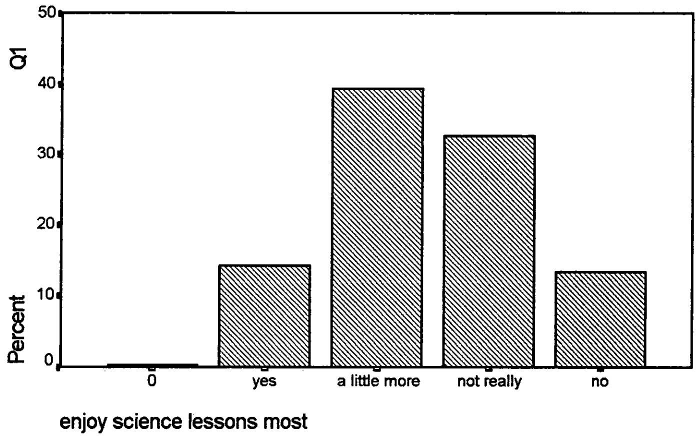
Did you do these tasks with your normal partner? *Yes* *No*

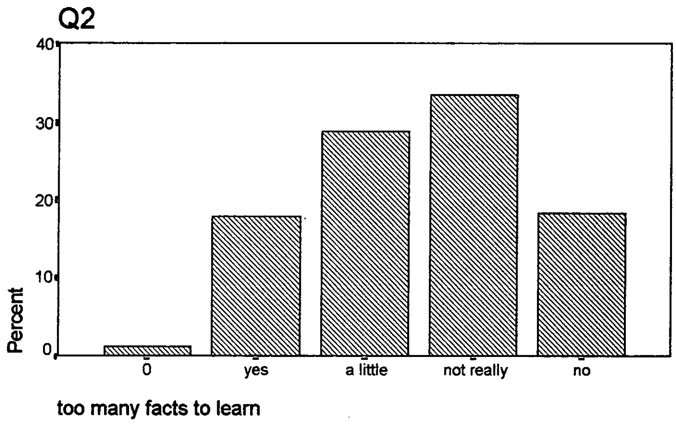
Who is your normal partner? *a boy* *a girl*

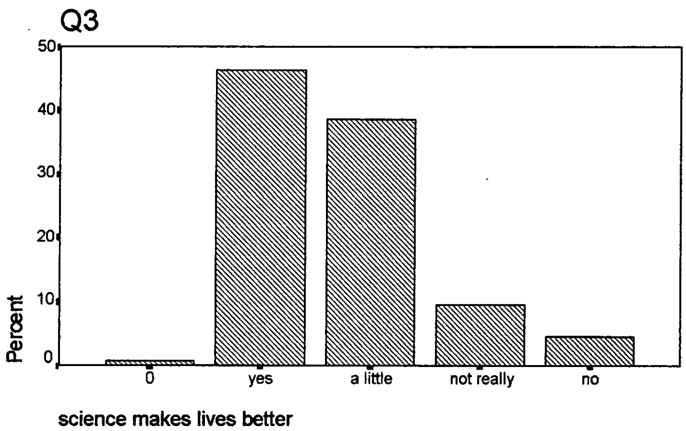
Who would you prefer to work with? *a boy* *a girl* *don't mind*

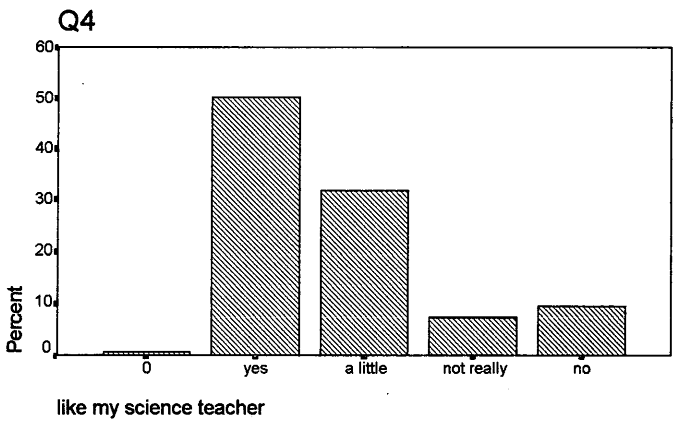
APPENDIX III

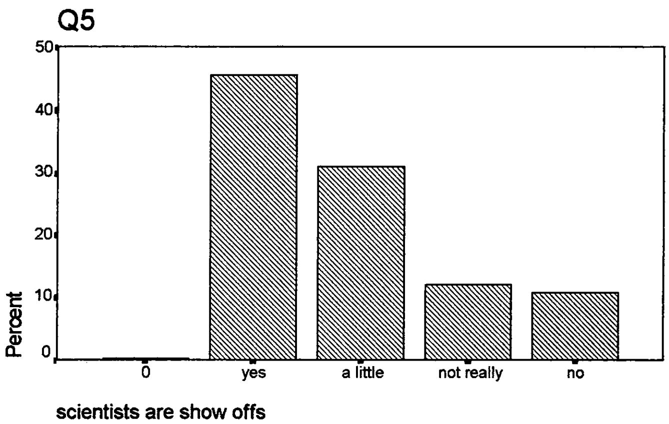
CHARTS

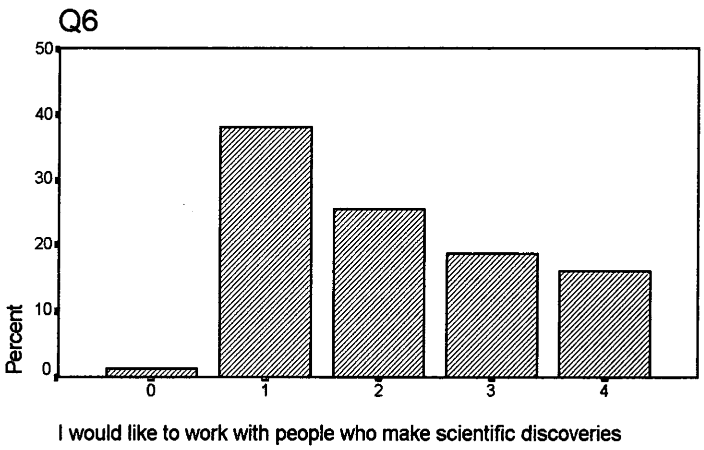

Q1
Percent
50
40
30
20
10
0
0
yes
a little more
not really
no
enjoy science lessons most

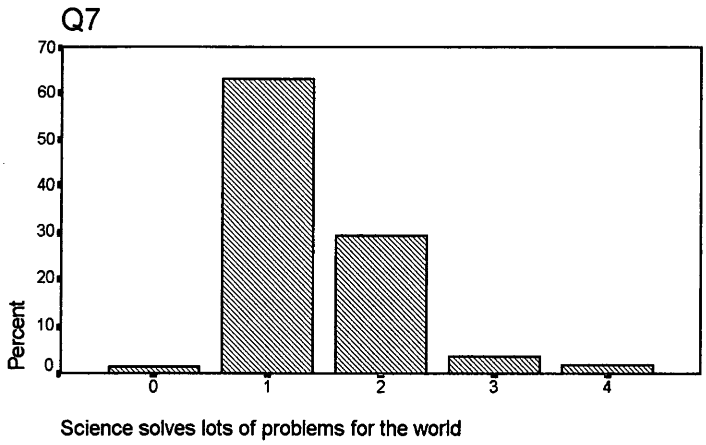

Q2
Percent
40
30
20
10
0
0
yes
a little
not really
no
too many facts to learn

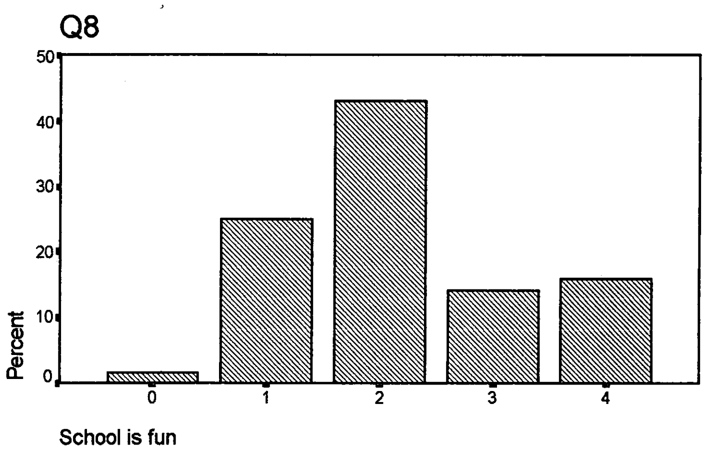

Q3
Percent
50
40
30
20
10
0
0
yes
a little
not really
no
science makes lives better

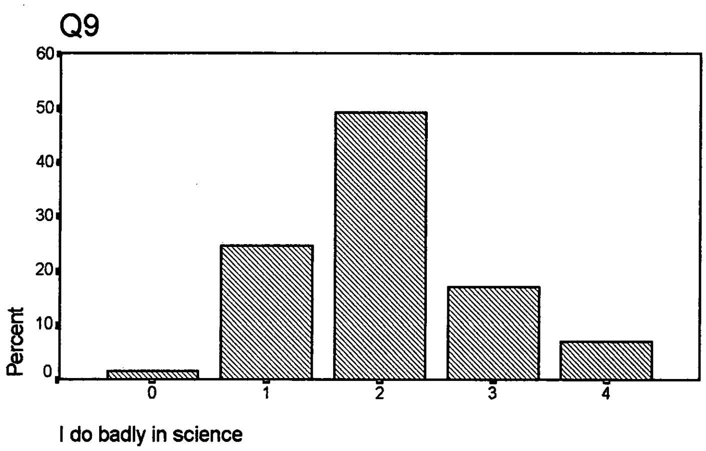

Q4
Percent
60
50
40
30
20
10
0
0
yes
a little
not really
no
like my science teacher

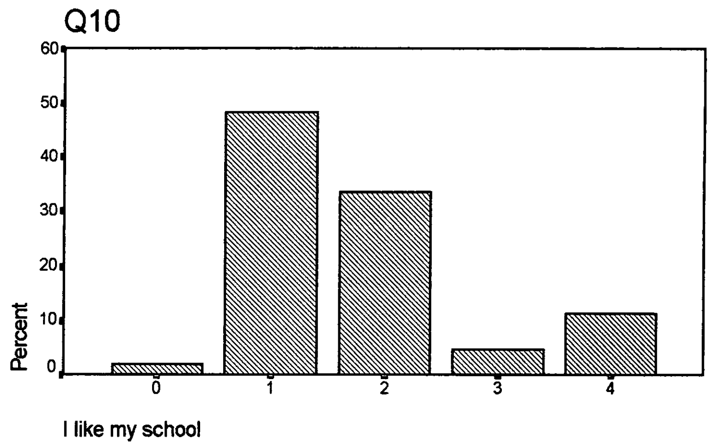

Q5
Percent
50
40
30
20
10
0
0
yes
a little
not really
no
scientists are show offs

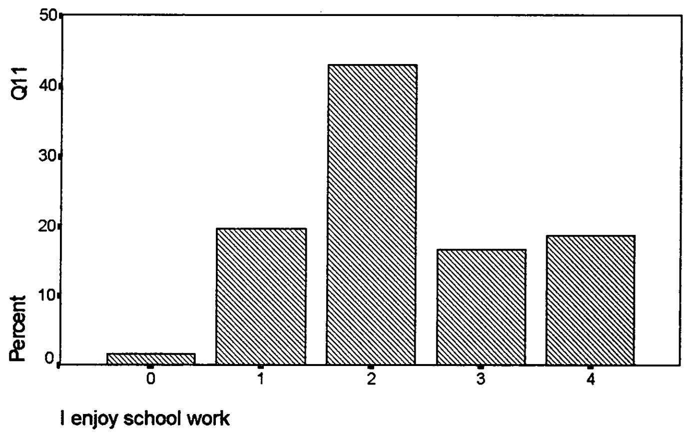

Q6
Percent
50
40
30
20
10
0
0
1
2
3
4
I would like to work with people who make scientific discoveries

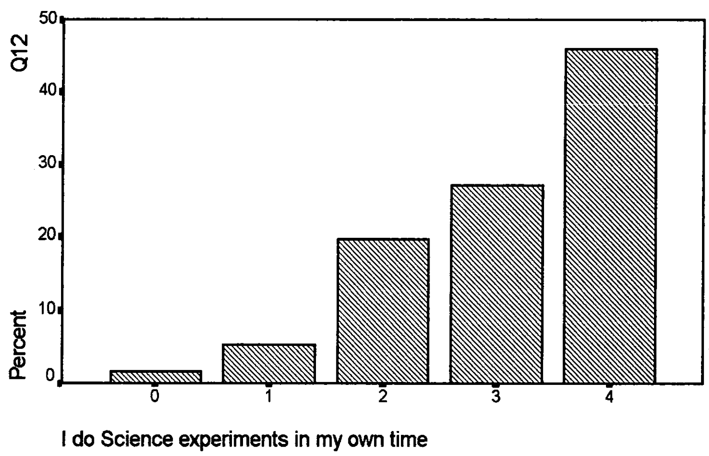

Q7
Percent
70
60
50
40
30
20
10
0
0
1
2
3
4
Science solves lots of problems for the world

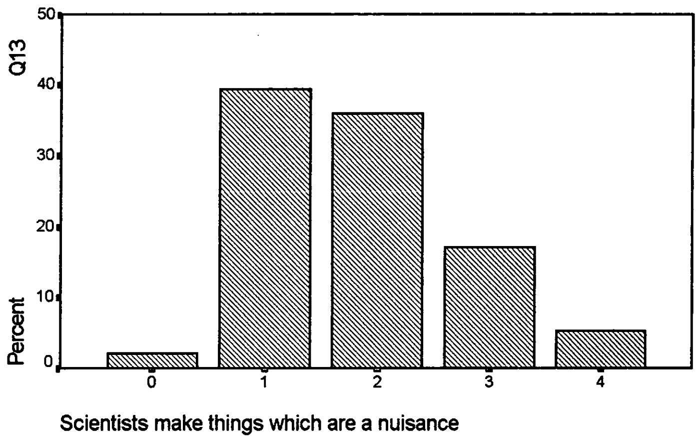

Q8
Percent
50
40
30
20
10
0
0
1
2
3
4
School is fun

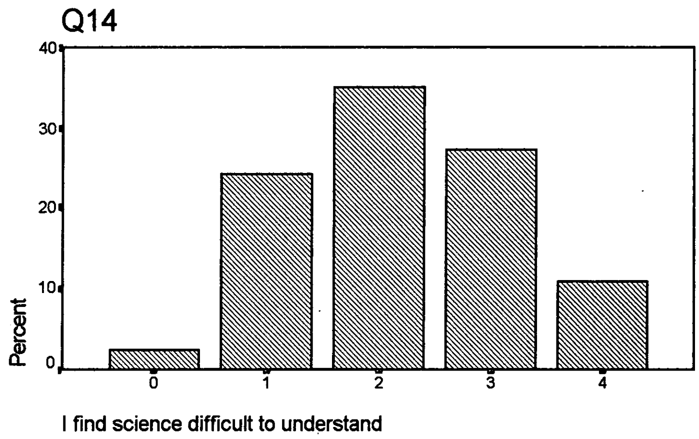

Q9
Percent
60
50
40
30
20
10
0
0
1
2
3
4
I do badly in science

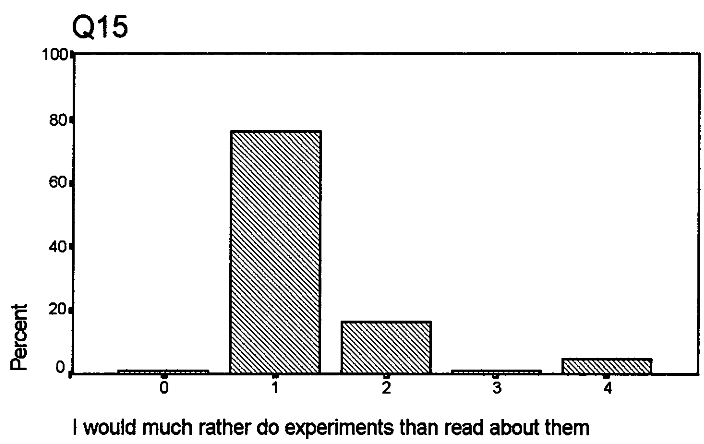

Q10
Percent
60
50
40
30
20
10
0
0
1
2
3
4
I like my school

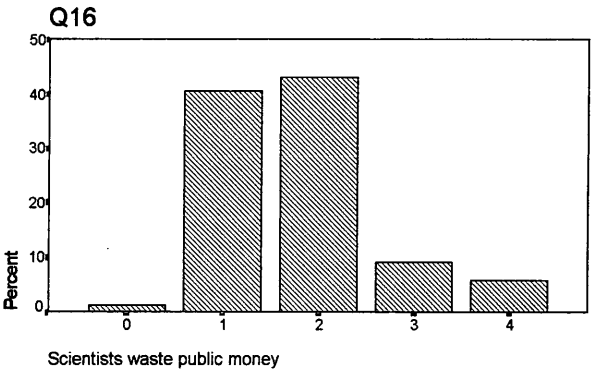

Q11
Percent
50
40
30
20
10
0
0
1
2
3
4
I enjoy school work

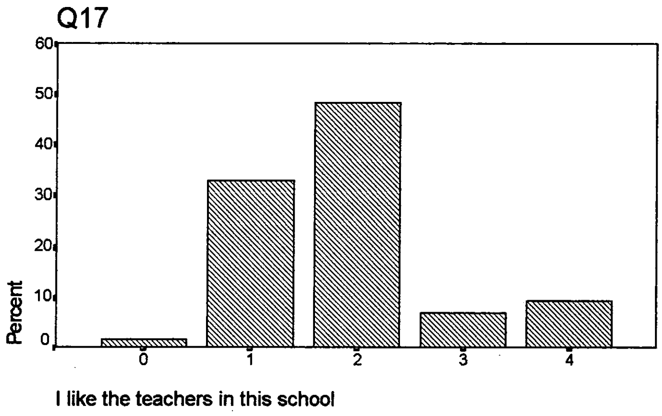

Q12
Percent
50
40
30
20
10
0
0
1
2
3
4
I do Science experiments in my own time

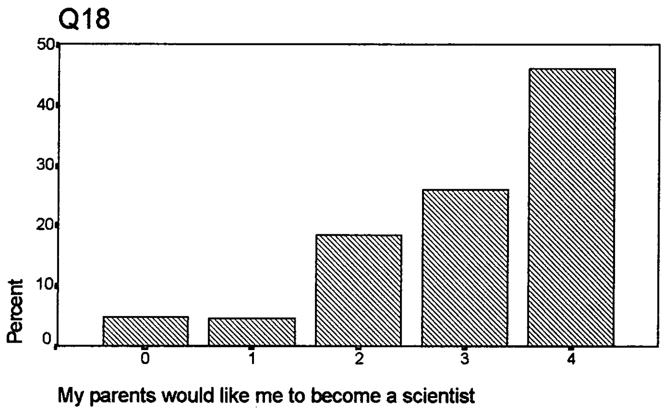

Q13
Percent
50
40
30
20
10
0
0
1
2
3
4
Scientists make things which are a nuisance

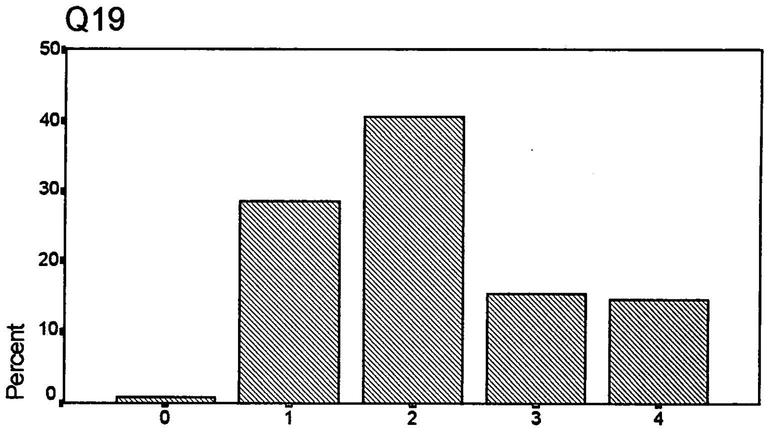

Q14
Percent
40
30
20
10
0
0
1
2
3
4
I find science difficult to understand


Q15
Percent
100
80
60
40
20
0
0
1
2
3
4
I would much rather do experiments than read about them

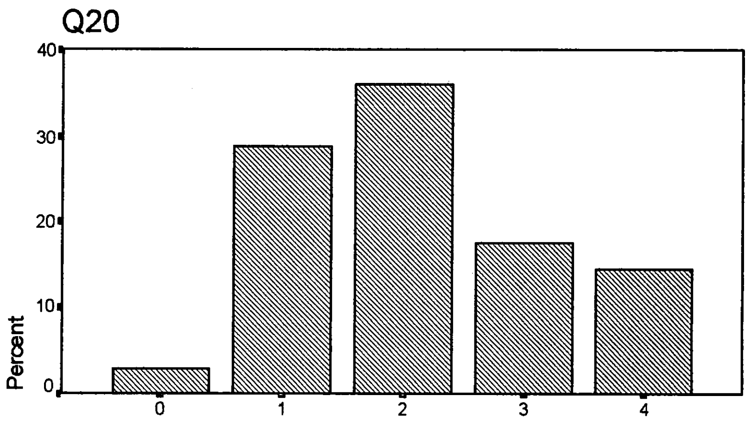

Q16
Percent
50
40
30
20
10
0
0
1
2
3
4
Scientists waste public money


Q17
Percent
60
50
40
30
20
10
0
0
1
2
3
4
I like the teachers in this school

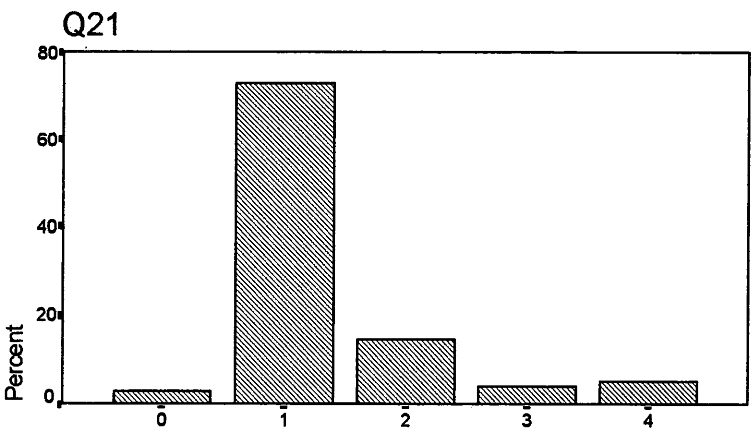

Q18
Percent
50
40
30
20
10
0
0
1
2
3
4
My parents would like me to become a scientist



I look forward to science lessons

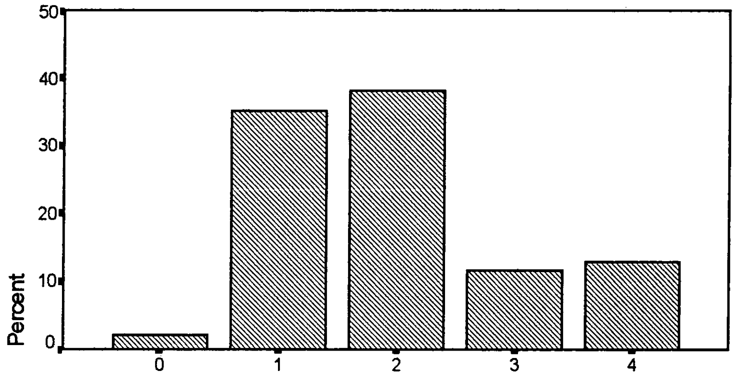


School is boring



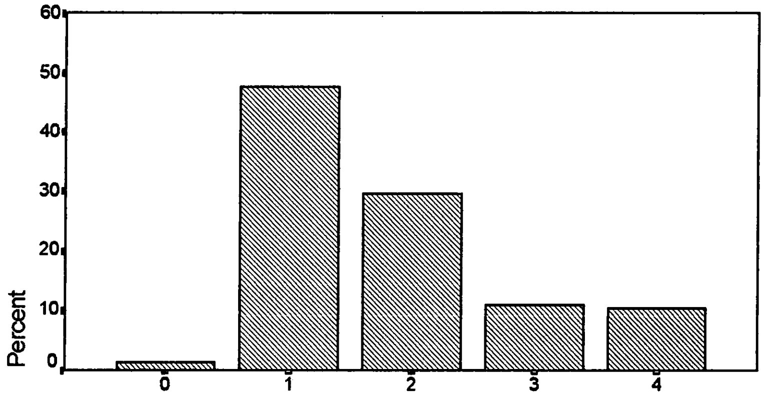
I would rather do an experiment than listen to a lesson

Q22



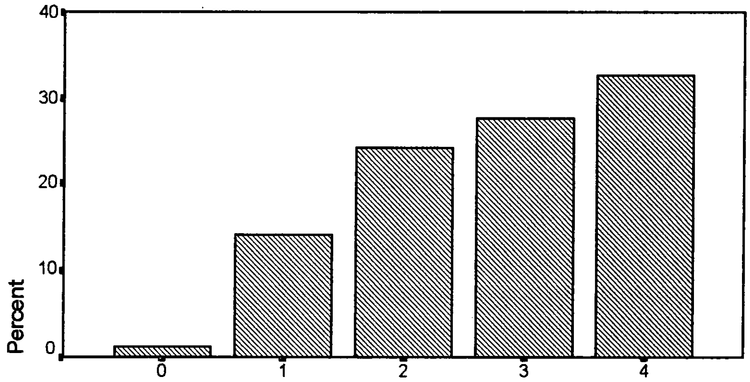
I enjoy working for my science teacher

Q23

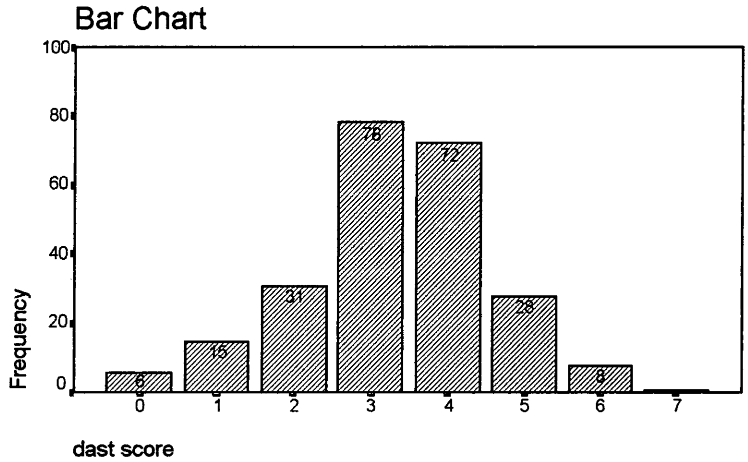


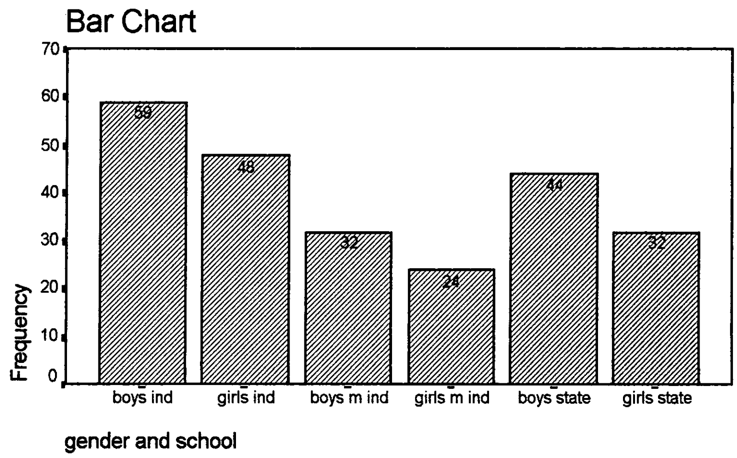
I would enjoy school more if there were no science lessons

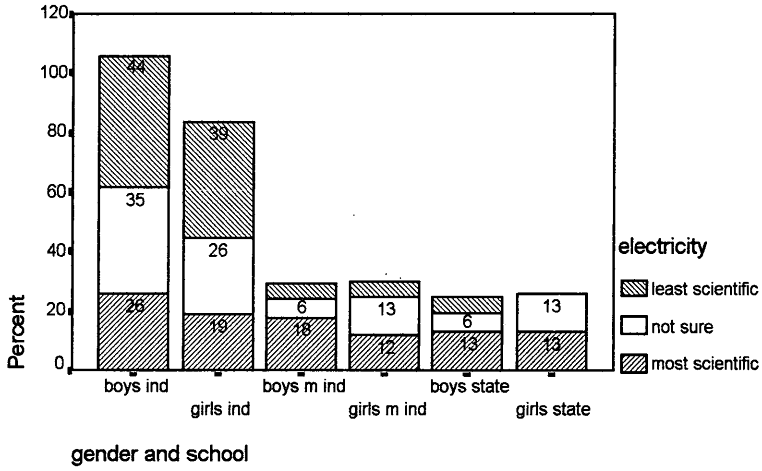
Q24



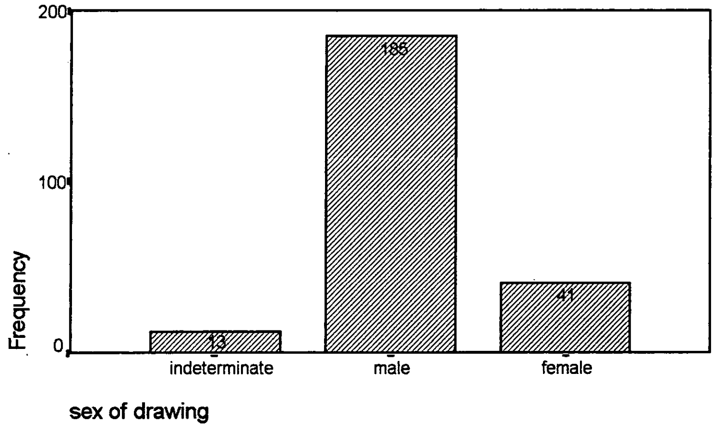
I would like to belong to a science club


Bar Chart
Frequency
100
80
60
40
20
0
6
15
31
76
72
28
8
0
1
2
3
4
5
6
7
dast score

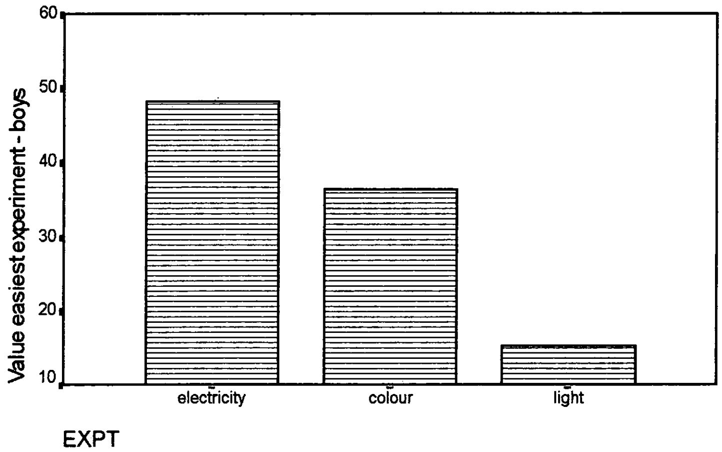

Bar Chart
Frequency
70
60
50
40
30
20
10
0
59
48
32
24
44
32
boys ind
girls ind
boys m ind
girls m ind
boys state
girls state
gender and school


Percent
120
100
80
60
40
20
0
44
35
26
39
26
19
6
18
13
12
6
13
13
13
boys ind
girls ind
boys m ind
girls m ind
boys state
girls state
gender and school
electricity
least scientific
not sure
most scientific

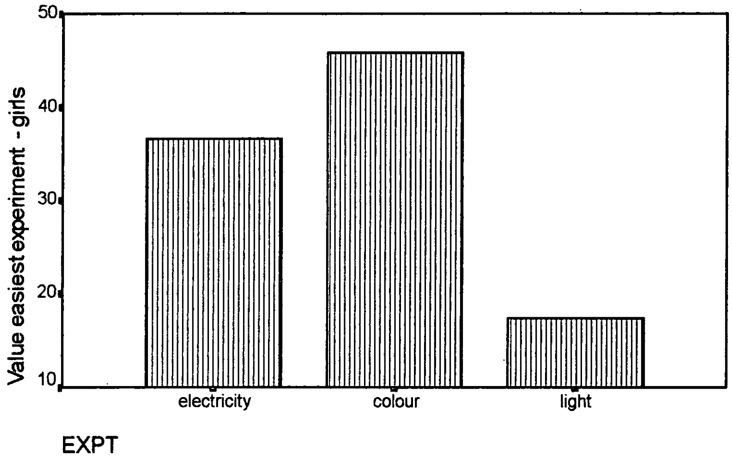
Bar Chart



200
100
0
Frequency
13
185
41
indeterminate
male
female
sex of drawing



60
50
40
30
20
10
Value easiest experiment - boys
electricity
colour
light
EXPT



50
40
30
20
10
Value easiest experiment - girls
electricity
colour
light
EXPT

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