Changing attitudes? A longitudinal study of pupils' attitudes to science between the primary and secondary phases of education.

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Abstract

The findings are reported of a 4-year (1995-1998) longitudinal study, conducted in three primary schools (Years 5 and 6) and a single comprehensive school (Years 7 and 8) in Oxfordshire, of pupils' *(n=71)* attitudes towards various aspects of school-based science. The objectives were to investigate whether the pupils', especially the girls', attitudes to school science had changed (particularly in the early secondary years) from those reported in the pre-National Curriculum research literature. Data on various aspects of school science, including attitudes to the individual biological and physical science topics in Years 5 to 7, were collected from the pupils via annual questionnaires and, for 36 pupils, from annual, semi-structured tape-recorded interviews. Year 6 pupils also provided some "mini-essays".

The cohort pupils' attitudes varied little from those reported in the pre-national Curriculum literature - science was regarded as a 'favourite' subject by very few pupils. The girls' lack of enthusiasm for the physical sciences, and the boys' disinterest in the biological sciences, were demonstrated. Some tentative links were suggested between the type of "out-of-school" activities, hobbies and interests recorded by the pupils and the pupils' attitudes to school science.

Data were also collected on the parental experiences of, and attitudes towards, science as well as the parents' involvement in science-orientated and 'tinkering' activities. There was a positive correlation between the Year 7 pupils' attitudes to the physical sciences and the fathers' attitudes to their secondary science education. Fathers still appeared to be the main 'tinkerers' - they were more likely to be involved with their sons (rather than their daughters) in joint science-orientated activities. Using multiple regression procedures on the "in-school" and "out-of-school" data, the types of "out-of-school" activities enjoyed by the primary pupils, together with the maternal involvement in such activities, were shown to be predictors of the pupils' attitudes to science. The importance of the pupils' perceived performance in science, together with gender (especially with the respect to the physical sciences) were identified as two of the main predictors of pupils' attitudes at the end of the study.

Finally, suggestions are made on how pupils' attitudes to school science might be improved by changes in the nature and delivery of the science curriculum.

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Abbreviations

AT	Attainment Target
A.P.U.	Assessment of Performance Unit
A.Q.A.	Assessment and Qualifications Alliance
A.S.E.	Association for Science Education
C.O.P.U.S.	Committee on the Public Understanding of Science
C.S.E.	Certificate of Secondary Education
E.S.R.C.	Economic and Social Research Council
G.C.E.	General Certificate of Education
G.I.S.T.	Girls into Science and Technology
H.M.I.	Her Majesty's Inspectors
I.E.A.	International Association for the Evaluation of Educational Achievement
L.E.A.	Local Education Authority
M.E.P.	Microelectronics Programme
N.C.C.	National Curriculum Council
N.F.E.R.	National Foundation for Education Research
O.F.S.T.E.D.	Office for Standards in Education
PoS	Programme of Study
PC	Profile Component
Q.C.A.	Qualifications and Curriculum Authority
R.O.S.L.A.	Raising of the School Leaving Age
R.S.A.	Royal Society of Arts
S.C.A.A.	Schools Curriculum and Assessment Authority
S.E.A.C.	Schools Examinations and Assessment Council
S.E.C.	Secondary Examinations Council
S.S.C.R.	Secondary Science Curriculum Review
T.V.E.I.	Technical and Vocational Initiative

Introduction

For many years, considerable concern has been expressed, particularly by the British government, about the public's poor perception of science and scientific issues (Council for Scientific Policy, 1968; Rothschild Report, 1971; Bodmer Report, 1985 and Cabinet Office, 1993). The apparent lack of public understanding about the nature of science, together with the projection of a negative image of science and scientists, have been related to the decline in the proportion of young people choosing to study science beyond age 16 and to a lack of enthusiasm for careers in science. This consequent reduction in the proportion of scientifically-literate personnel in the nation's work force has, in turn, been blamed for the lack of UK competitiveness in the fields of science and technology abroad. Concerns that these negative attitudes towards science were mainly established whilst still at school (Selmes, 1969; Ormerod and Duckworth, 1975; Gardner, 1975 and Haladyna et al., 1982) have led to increasing research interest (Department of Education and Science, 1986; Kelly, 1986 and Keys, 1987) in pupils' attitudes towards, and achievement in, science during the years of compulsory schooling.

The initial stimulus for this research proposal came from personal observations as a primary trained science teacher on transferring, in the early 1990s, from middle school (age 9-13) to secondary school (age 11-16) teaching. Whilst younger pupils generally appeared to have quite positive attitudes to science-based topics, the enthusiasm for science compared with other areas of the curriculum seemed to decline as the pupils progressed towards their G.C.S.E courses. The majority of pupils, particularly the girls, appeared to have "switched-off" science, particularly the physical sciences, by the age of 14.

One of the aims of the National Curriculum for Science, put in place as a result of the Education Reform Act (1988), was to improve pupils' image of, and enthusiasm for, the sciences. In 1993, a first, tentative research proposal was put forward to investigate whether pupils (particularly girls) who had been exposed for almost all of their primary and lower secondary education to this new National Curriculum for Science, with its attention to relevance and 'building on' existing knowledge, would show more positive attitudes to science by the age of 14.

Following an initial examination of the literature on the nature of attitudes (Chapter 1) and the background to the introduction of the National Curriculum for Science (Chapter 2), a more detailed review of the research literature on pupils' attitudes to science was undertaken (Chapter 3). This confirmed that, whilst several studies of pupils' attitudes had been undertaken over the previous three decades, in the majority of these studies the emphasis had been on trying to identify the reasons underlying pupils' "option choices" at age 14 – a choice which was no longer relevant for the vast majority of pupils now that science had been designated a core, curriculum subject in the National Curriculum.

As a result of the review, proposals were made to initiate a 4-year longitudinal study of attitudes to the physical and biological sciences in some pupils who would be exposed to the compulsory National Curriculum during both their primary and secondary years and to compare the findings with those reported in the pre-1990s literature for pupils of a similar age group. Personal observations made in the classroom, supported by those in the relevant research literature, particularly those of Kelly (1986), suggested that the physical sciences (chemistry and physics) should be considered separately from the biological sciences and that gender should be a key factor for analysis. The main emphasis of the research would be on these "in-school" factors including the pupils' attitudes to various aspects of their science lessons and their attitudes to science compared with those to other subject areas (particularly the humanities in the primary years).

Pre-dating the National Curriculum were some studies (e.g. Comber and Keeves, 1973 and Keys 1987) which, although not longitudinal in design, had incorporated some analyses of the contribution made by parental attitudes to science (and other home factors), as well as "out-of-school" activities, to the pupils' own attitudes to science. Attempts would therefore be made in the proposed longitudinal study to relate various measures of the pupils' attitudes to science to parental experiences of, and attitudes towards, their own science education as well as to some other "out-of-school" and home-based activities.

These considerations therefore defined the objectives of the proposed research - it would be a longitudinal study which would:

- be conducted with pupils who had been exposed to the National Curriculum during the period of study;
- take separate account of attitudes towards the physical and biological sciences;
- take due account of gender as a factor for analysis;
- compare pupils' attitudes towards various aspects of school science with those to other areas of study;
- span both the primary and secondary phases;
- be of at least three years' duration;
- include an examination of the relationship if any, between pupils' attitudes to various aspects of science and their "out-of-school" hobbies, interests and activities.
- include an examination of any relationships between pupils' attitudes to science and parental attitudes towards, and experiences of, science including parental involvement in the pupils' "out-of-school" activities.
- comment on the changes, if any, between the findings of the study and those of attitudinal studies undertaken before the inception of the National Curriculum.

Chapter 1 which follows comments, *inter alia,* on the lack of understanding of science and scientific issues by both pupils and the public at large. It is suggested that improvements will only be achieved in this respect by encouraging pupils to adopt more positive attitudes to science before the end of their compulsory schooling.

Chapter One: Science - perceptions of public and pupils

Introduction

> "Perhaps Science is most clearly defined by saying that it is firstly a vast collection of facts expressed in exact and unambiguous language in such a manner that any one who cares to take the trouble can test the truth; and secondly a collection of rules or laws which express the connection between these facts."
>
> (F. Sherwood Taylor, 1936, "The World of Science", Introduction)

Sherwood Taylor's rigid, somewhat daunting, definition of science was written at a time when, in England and Wales, relatively few pupils (only those at public schools or state grammar schools) would have studied 'science' beyond an elementary level and, for the majority of the public, science remained an inaccessible mystery. Just over twenty years later, the continued existence of a divide[1] between scientists and other professions and a lack of understanding as to the nature of science and the role of scientists was acknowledged in C.P. Snow's (1959) Cambridge lecture on "The Two Cultures and the Scientific Revolution".

1.1 The public view of science

More than a decade after Snow's lecture, the concerns expressed in the Dainton Report (Council for Scientific Policy, 1968) and the Rothschild Report (1971) about the general public's lack of understanding of science and the need to raise the profile of scientists met with a response at Government level (Cabinet Office, 1972). However, it was not until 1985 that the Bodmer Report on "The Public Understanding of Science" (Bodmer Report, 1985) initiated some positive Government action and a standing Committee on the Public Understanding of Science (C.O.P.U.S.) was established which became responsible for, *inter alia,* the introduction of the Science, Engineering and Technology (S.E.T.) initiatives.

It was suggested in the Report (Bodmer Report, 1985) that there should be more provision for primary science and that industry, together with the various scientific organisations, should participate to a greater extent in school activities and visits and in the creation of more courses for the general public to explain, through the use of the mass media, the significance of many recent developments in science.

[1] in which "British science had effectively become a marginalized subculture-misunderstood, underappreciated and underpaid" (see J. Naughton, 1997, p.1).

In 1993, as the outline proposal for this longitudinal study was being drafted, the Government White Paper "Realising our Potential" (Cabinet Office, 1993) was published. This was the first White Paper published as a result of an in-depth review of the policy on, and the organisation of, science since the 1970s – it focussed on the understanding and application of science as an essential foundation for national prosperity as well as on the contribution of science (and engineering) to the improvement of public services and the quality of life. The need to improve the public understanding of science was also re-iterated:

> "As a country we have suffered in the past from a culture which placed too low a value on education and training in general, and which gave insufficient recognition to the importance of knowledge and understanding of scientific and technological issues."
>
> • (Cabinet Office, 1993, Chapter 7, p.53)

One of the first major attempts[2] to increase the public understanding of the nature of science through the use of television had been made by Dr. Jacob Bronowski in the 1970s but some of the negative views of 'science' still being cited in the media over twenty years later were summed up by Lewis Wolpert[3]:

> "Science is not the mere accumulation of facts; it is an imaginative, creative and difficult enterprise..............we scientists have to learn to understand public concerns and communicate more than we have so far done...........it is our social obligation, because we have the priviledged position of access to knowledge not easily accessible to others."
>
> (Wolpert, 1994, p.4)

After the fieldwork for this longitudinal study had been completed, the Economic and Social Research Council (E.S.R.C.) initiated a 'New Opportunities'[4] Programme on the Public Understanding of Science. Its objectives were, *inter alia*, to encourage the exchange of ideas from scientific research to policy and practice, and hence to its potential users including the general public. A two-week Global Internet conference highlighted the need for scientists to devote more effort in explaining their work, for example on bovine spongiform encephalopthy (B.S.E.), to a wider "non-expert" audience. The importance of sharing scientific discoveries with, and capturing the interests of, young people was also emphasised.

[2] "The Ascent of Man", published under the same title in book form (Bronowski, 1973)
[3] Chairman of C.O.P.U.S. (1992)
[4] New Opportunities Programmes provided resources to build on previous investments in the social sciences.

Data arising from the Second International Science Study conducted in 1984 had indicated that the overall attitudes of 'A'-level students[5] towards careers in science were 'unexpectedly low' (Keys, 1987, p.119) and a common strand throughout all the later reports on the public understanding of science was the need to stimulate in young people, *before* the end of their compulsory schooling, a more positive view of science and by this means to encourage a greater interest in, and uptake of, the sciences post-16. Without positive attitudes during the years of compulsory schooling it was asserted that it was unlikely that pupils would be inclined to take up a science-based career.

The increasing concern about the fall in the number of students taking up scientific careers was the main focus of the White Paper "Realising our Potential" (Cabinet Office, 1993). A decade later, the rapid advances in communication and computer-based learning, together with the availability of interactive science centres and the introduction of "fun" science activities as part of "Science Weeks[6]" in schools, have offered children more opportunities to acquire a better understanding of science and scientific issues and to stimulate their interest in science as a career.

1.2 Pupils' views of science and scientists

The idea that any improvement of the public's understanding of, and enthusiasm for, science would be best brought about by positive action during their days of compulsory schooling was an issue which had been raised by Bernal[7] some sixty years previously (Gornall and Thomas, 1998). Bernal had promoted greater dissemination of current scientific developments through the press, 'wireless' and cinema and more emphasis on science in schools and visits to laboratories by pupils and adults. He believed that reforms in school education would give a better foundation for the public's proper understanding of science.

The improvement of schoolchildren's understanding of science, thus enabling them, as adults, to be better informed on scientific issues, was one of the key points in the King's College Report (Osborne and Collins, 2000), published after the fieldwork for this longitudinal study had been completed.

[5] Post-16 students taking two-year Advanced – level ("A"-level) courses in the sciences.

[6] In an attempt to raise the profile of science, in 2002 the traditional "Science Week" was extended to a "Science Year."

[7] then Professor of Crystallography (Birkbeck College)

> "We live in a scientific world where youngsters growing up now will, and should, be able to read the press and have a basic understanding of the dilemmas that are coming up.........They should be able to make informed choices about those things, so they need that level of interest and that level of understanding."[8]
>
> (Osborne and Collins, 2000, p.99)

More recently, referring to the crucial role played by school education in restoring the relationship (or 'dialogue') between science and the public, the Chairman[9] of the House of Lords Select Committee's enquiry 'Science and Society' commented:

> "Lingering attitudes from a person's schooldays are a major influence on his or her adult views of science. We found ourselves concerned, not so much with the 10 per cent of pupils who aim at science A-levels, followed by a degree in science, but with the 90% who have other ambitions and goals. It is amongst that 90% that are mainly found those who, in later life, most mistrust – and even despise – science and scientists."
>
> (Jenkin, 2002, p.23)

The adult 'mistrust' of scientists referred to by Lord Jenkin may, therefore, be founded on negative attitudes to science formed at a much earlier stage. Over thirty years ago, Selmes (1969) showed that 13- and 14-year-old pupils perceived scientists as 'mad' and there is still a tendency for scientists to be viewed by both children and adults as 'white-coated obsessional males with glasses' (Wolpert, 1994) or 'geeks' (Gill, 1996). Although many researchers (Bradley and Hutchings, 1973; Hewison, 1982; Keys, 1987 and, more recently, Wiggins and Wright, 2000) have noted that pupils generally regard scientists as "clever", television has been accused of portraying scientists "as eccentric, and either negative and malevolent or odd and benign" (Young, 1992).

Lord Jenkin's comments that a major influence on adults' views of scientists and science may be the 'lingering attitudes' from the years of school education, echoed Bernal's argument (Gornall and Thomas, 1998) for a greater awareness of scientific issues to be encouraged during pupils' schooldays. An improvement, during the years of compulsory education, in the understanding of science and the role of scientists in society, would be expected to stimulate more positive attitudes to science which would hopefully continue into adulthood.

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[8] 'Ben' (parent from a science group)
[9] Lord Jenkin of Roding

Although there is a general consensus in the literature that attitudes are formed at an early age (Summers, 1970; Warren and Jahoda, 1973 and Eagly and Chaiken, 1993), for more than a century, there have been many attempts to define what is meant by the term 'attitudes'.

1.3 Attitudes: a 'hidden mechanism'?

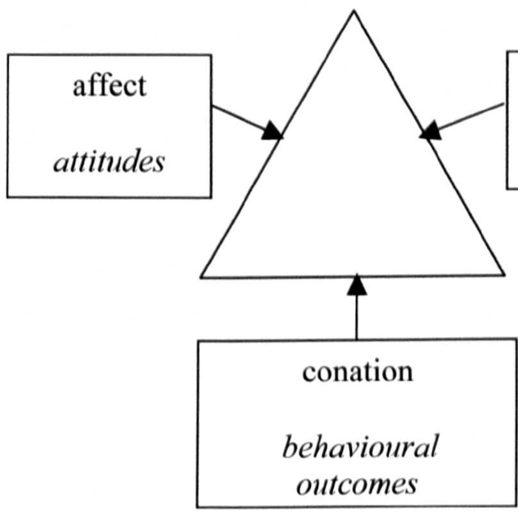
According to Allport (1954, p.22) it was the influence of Freud which "endowed attitudes with vitality.....with the onrushing stream of unconscious life" but Herbert Spencer was one of the first psychologists to use the word 'attitude' to describe the position, or view, held by an individual during a discussion or argument:

> "Arriving at correct judgements of disputed questions, much depends on the attitude of mind we preserve while listening to, or taking part in, the controversy."
>
> (H.Spencer , 1862, "First Principles", Vol I, 1, (i), quoted in Allport, 1954, p.22)

At about the same time as Spencer's work was published, Wilhelm Wundt concluded (see Allport, 1954, p.21) that there seemed to be no representation of attitudes in the conscious mind other than a 'vague sense of need, or some indefinite and unanalysable feeling of doubt, assent, conviction, effort or familiarity.' They could not be identified either as 'sensations' or any 'combination of sensations, imagery or affections'. The data, collected by introspection, was later criticised for lack of scientific rigour but there was a gradual move towards an acceptance that attitudes did include some sort of real, albeit undefinable, 'feelings'. The 'classical conditioning mode' of attitude change (Staats and Staats, 1958) assumed that an 'attitude' was an affective response which was the result of repeated associations between an attitude object and an unconditional stimulus. Reich and Adcock (1976, p.12), regarded the concept of attitude as an 'intervening' or 'mediating' variable which was assumed to exist but which was 'not directly observable'. More recently, however, Eagly and Chaiken (1993) have defined attitudes as an 'evaluative tendency' (see Fig.1.1).

Fig.1.1: Observable and inferred responses (after Eagly and Chaiken, 1993)

Fig. 1.2: The three components of attitudes



They commented that, although an 'attitude'[14] might be considered to be simply a 'conceptual convenience', it was more likely to be equivalent to some latent process or 'hidden mechanism' (a phrase used earlier by Thomas, 1971, p.10) which involved various psychological and physiological processes in the mind but which could not be directly observed.

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[10] A linear (unidimensional) scale is normally used in the *measurement* of attitudes the individual responses being recorded along a single dimension (i.e. favourable ↔ unfavourable) – see Chapter 4.

[11] the **affective:** what a person *feels* about the attitude object, how favourably or unfavourably it is evaluated, reflecting its place in the person's scale of values.

[12] the **cognitive:** what a person *believes* about the attitude object, what it is like objectively.

[13] the **behavioural (conative):** how a person actually *responds* to the attitude object based on the affective and the cognitive.

[14] a 'predisposition to respond' to an object, rather than the actual behaviour towards it (Summers, 1970).

> " 'Attitude' is used by most social psychologists as a 'hidden mechanism' representing a residue of experience of transaction with an object, which in turn will have some degree of influence on consequent behaviour."
>
> (Eagly and Chaiken, 1993, p.6)

1.4 Attitudes and science

Ajzen and Fishbein's (1980) 'theory of reasoned action' focussed on the difference between attitudes *towards* a specific object and attitudes towards *involvement* with that object – this would suggest, for example, that attitudes towards *doing* science would better predict behaviour than attitudes *towards* science itself. Although the 'triadic' model suggests that attitudes give rise to some degree of behavioural outcome, e.g. the decision whether, or not, to proceed further with a study of the sciences, Eagly and Chaiken (1993) commented that a person's attitude may *not always* influence behaviour, particularly if the attitude object has little emotional significance to the individual. They argued that the lack of correlation between attitude and behaviour (see also Petty, 1995) could sometimes be explained by the fact that the stimulus object was insufficiently specific - attitudes were often measured to a group of objects rather than a single object - and yet behaviour was directed to a specific example of the group.

Simon (2000, p.106), referring to the work of Potter and Wetherall (1987), has also suggested that peoples' attitudes might not necessarily be related to the behaviours demonstrated. A pupil may, for example, show an interest in science but avoid showing this in his/her peer group because of worries about being marginalized by the group. The pupil's motivation to adopt a certain style of behaviour may be greater than the motivation linked with the attitudes (e.g. a positive interest in science) expressed. Sometimes, the expected consequences of the behaviour may cause the behaviour to be modified so that it is inconsistent with the attitudes held. According to Simon (2000, p.106) behaviour, rather than attitude, has therefore tended to attract more research.

Abdou (1984, p.35) noted that the lack of a clear definition of attitudes as related to science was due to the overlap of broad categories of attitudes e.g. 'scientific attitudes', 'attitudes towards scientists', 'attitudes towards the subject of science' etc. (see Gardner, 1975). After the initiation of this research study, Simon (2000) reviewed the literature on attitudes to science and suggested that there was a discrepancy between attitudes to *school* science and attitudes to science (many surveys have shown the latter to be positive) and commented

(Simon, 2000, p.105) that thirty years of research into students' attitudes to science "has been bedevilled by a lack of clarity about what attitudes to science are."

Most of the studies on the outcomes of different teaching approaches in science have been associated with the effects of these approaches on pupils' *achievement* (Peaker, 1971; Comber and Keeves, 1973; Keys, 1987; Harris et al., 1997 and Keys et al., 1997)[15]. The influence of various teaching strategies on *attitudes* to a particular subject area, and the effects of those attitudes on a pupil's decision whether, or not, to continue with science, have been documented to a lesser extent.

1.5 Learning and understanding in science: personal construct psychology

Pupil disaffection with science and the need to improve the image of, and attitudes towards, science is not a new phenomenon. Over sixty years ago the negative appeal of science lessons and the disappointing number of pupils continuing to study science to a higher level was noted by the Consultative Committee on Secondary Education:

> "The teaching of science has lost close touch with life itself, and for this reason has often failed either to give the knowledge required or to stimulate pupils' interest."
>
> Department of Education and Science (1938): 243.

By the outbreak of the Second World War, problems associated with pupils' negative attitudes towards the study of the sciences and the uptake of science beyond the end of compulsory schooling had, therefore, already attracted some attention. In the immediate post-war period, as the government was anticipating a large expansion in tertiary science education, little seemed to have changed either in the pupils' attitudes to science or, more fundamentally, how science was taught in the schools (Hislop and Weeks 1948a, 1948b). More recent research (e.g. Solomon, 1983 and Salmon, 1995) on the mechanisms by which pupils develop their understanding of, and attitudes towards, school science has however enabled teachers to consider alternative ways of delivering the science curriculum which might have beneficial effects on pupils' attitudes and, hence, future career choices.

By the mid-1950s, a new approach to the learning process based on George Kelly's 'personal construct theory', offered some new ideas on how pupils came to 'know' the world and how they related to it through their own 'networks of meaning'. This

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[15] see Chapter 3

'constructivist' theory had implications for the future teaching and learning of science and, ultimately, for effecting some change in pupils' attitudes.

Kelly's 'constructive alternativism' contrasted with what he termed the 'accumulated fragmentalism' approach which he felt was common in education at that time and which involved the accumulation of several strands of unrelated, 'fragmented' factual knowledge ('nuggets of truth') which had no inter-relationship between the fragments (Salmon, 1995). The suggestion was that the 'accumulated fragmentalism' approach was detrimental to pupils' learning – it offered no continuity and may be one of the reasons for pupils' disenchantment with science. Kelly felt that knowledge, and hence 'science', could be interpreted in many different ways according to the person's particular cultural environment; building up constructs from the child's point of view was more likely to instil positive attitudes to science. These ideas were based on Vygotsky's view that account should be taken, not only of the individual's interaction with the external world but also of the interactions, particularly through language, within the immediate social world of the individual (see also Leach and Scott, 2000, p.44).

The need to listen to children's views, as opposed to asking them simply to respond to questions, was emphasised by Glenny (1995) and the importance which she and others have placed on personal construct psychology as a mechanism which provides 'a structure that gives children a safe context in which to respond' (Glenny, 1995, p.7) informed some of the interviewing strategies later employed in this longitudinal study (see Chapter 4). The constructivist approach to teaching, which encourages students to be 'active constructors' (Frost, 1995, p.5) of their own knowledge, is based on the notion that 'cognitive dissonance' (Frost, 1995, p.6) is necessary for learning to take place. The discovery by pupils that their ideas do not make sense gives them the motivation to resolve the conflict.

Constructivist teaching, as a tool for enhancing pupils' learning experiences, has however met with considerable opposition (Posner et al., 1982; Millar, 1989 and Driver et al., 1994). Watts et al. (1997) later commented (p.57) that learning through constructivist processes was "not something a teacher can do for them; teachers cannot give learning to pupils". Hodson and Hodson (1998a) pointed out that positive teacher intervention was often needed for pupils to construct their own knowledge and to access the level of understanding required. They suggested that simply asking students to "make sense of their world" might be insufficient to count as 'worthwhile' science education. They cited the work of Matthews (1993, 1995) who had suggested that, because of its emphasis on the *personal* understanding of phenomena and events, constructivism tended to lack emphasis on the importance of *understanding* in science.

1.6 Understanding science and pupils' 'life-worlds'

Solomon (1983) had commented (in her work on energy concepts) on the difficulty experienced by pupils who were trying to cope with the transition between two different explanations of scientific phenomena - only with great difficulty were most students able to move between their 'life-world'[16] and 'scientific' domains. Salmon (1995) suggested that teachers often brought their own values, assumptions and particular meanings into the classroom - they needed to relate to the very different 'meaning-worlds' of the pupils and to help pupils to form their own constructs by making connections between the 'action knowledge'[17] of everyday experiences and the specialised knowledge of classroom science:

> "For what we know we know in the end about ourselves. When particular ways of knowing, particular stances[18] towards the world, feel somehow at odds with one's own familiar positions, they cannot be taken on. Knowledge which cannot be fitted into personal identity must be ruled out."
>
> (Salmon, 1995, p.8)

1.7 Potential scientists and 'Fatima's rules'

When the culture of science is different from the pupil's 'life-world' view, an alienation from school-based science may result. According to Larson (1995), pupils who were trying to assimilate the 'school' views of science (in order to achieve high test marks) without any detriment to their own indigenous views often adopted particular games which were played according to specific rules (which he called "Fatima's rules" after a particular chemistry student). Pupils who used "Fatima's rules" memorised key facts and used various strategies to avoid the need to construct scientific concepts. These pupils, called "Other Smart Kids" by Costa (1995), generally found science irrelevant to their personal

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[16] Schutz and Luckman (1973)

[17] Barnes (1986), quoted by Salmon (1995)

[18] The early literature equated 'attitudes' and 'stances' (as used by artists to describe the physical posture of the body in painting and sculpture) but this was discounted by Allport (1954, p.24) who suggested that attitude was ' a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related'.

lives, but they were able successfully to 'cross the border' between the two worlds by using these rules or by constructing schemata in the long-term memory which were only accessed when absolutely necessary (for example in a science examination). Other pupils, called "I Don't Know"[19] pupils, were well motivated and did not wish to appear stupid so they retained their 'life-world' concepts whilst, simultaneously, memorising certain procedures. For perhaps 90% of pupils (called "Outsiders" by Costa) 'crossing the border' from the microculture of family into the microculture of school science was believed to be impossible and 'dropping out' was often seen as the only option.

The research would suggest that if pupils are to build up, and retain, positive attitudes to science then they may need help to accommodate unfamiliar concepts outside their 'life-world' and to see the relevance of what they are expected to learn. These ideas differ little from some recommendations for raising pupils' enthusiasm for science some 60 years ago:

> "It therefore follows, as a fundamental principle, that the teacher must start if possible from the pupils' background of experience.......he must make scientific knowledge appear immediately useful, practical and valuable, and not present it as abstract academic knowledge divorced from everyday life."
>
> (McKenzie, 1941, p.245)

1.8 Safaris and 'crossing the border': more recent research

If pupils lack understanding of scientific concepts it is unlikely that their attitudes to science will be positive and that they will elect to study science beyond the age of compulsory schooling. Watts et al. (1997) used a strategy of 'question-based learning' to analyse conceptual changes. Learners' questions were categorised into three types of questions *(exploration, elaboration and consolidation)* and analogies were drawn between the type of question asked and different life experiences such as going 'on safari'. For example, pupils who asked 'Exploration' questions seemed to be fairly confident about their understanding of a topic and they tried to extend their knowledge and test their constructs by launching a few 'sorties' or 'safaris' into neighbouring territory (Watts et al., 1997, p.59). Other pupils, whose questions came into the 'Elaboration' category, attempted to reconcile the different ideas to which they had been exposed; 'Consolidation' questions were asked by pupils who tried to express their thoughts in order to understand concepts but these pupils often seemed to require the teacher's reassurance that they had followed the main points of the argument.

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[19] so called because this was their typical response to questions about school and science.

Referring to the work of Solomon et al. (1996) on the difficulty experienced by most pupils to move between their 'life-world' and 'scientific' domains, Aikenhead and Jegede (1999, p.277) believed that it was possible, however, for some students concurrently to hold both a 'scientific' and an 'indigenous' view of the world.

> "By reflecting on the two settings and their concomitant concepts ....a student may easily cross the cultural border between home and school science."
>
> (Aikenhead and Jegede, 1999, p.280)

They defined four types of border crossing, those which were: *smooth* (no apparent recognition of a border between the two cultures); *managed* (some discomfort in the other culture and a need to handle the crossing carefully); *hazardous* (possible loss of self-esteem and the need to adopt various coping strategies) and *impossible* ('psychological pain' was likely to be involved and therefore the crossing might be best abandoned). Aikenhead and Jegede then considered some of the requirements for successful 'border crossings' between two cultures. Flexibility, for example being able to be a different person in different worlds, and 'feeling at ease' (Lugones, 1987) with the norms or language of the other culture, were also necessary to pass smoothly from one world to another.

> "To travel between worlds is to shift from being one person in one context to being another person in another context, without losing our self-identity as the same person we remember in our most familiar world. To travel between worlds[20] is to cross cultural borders"
>
> (Aikenhead and Jegede, 1999, p.273)

1.9 Research and proposals for a National Curriculum

Although much of this research on pupils' strategies for dealing with different views of science was only conducted in the 1990s, the use of personal construct psychology to facilitate pupils' identification with scientific issues was already well established by the late 1980s. By this time proposals were being finalised to adopt a new, compulsory National Curriculum for Science which offered the opportunity to re-think the content and delivery of school science, to make it more relevant to pupils' lives and thus to improve pupils' attitudes towards the sciences in general. The development of this National Curriculum for Science for use in English and Welsh schools is discussed in detail in Chapter 2.

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[20] 'world-traveling' (Lugones, 1987)

Chapter One: Science – perceptions of pupils and public

1.10 Summary

The apparent lack of understanding, by both pupils and the public, about the nature of science was discussed. It was suggested that improvements in the public understanding of science will probably only be achieved by encouraging pupils to adopt more positive attitudes to science before the end of their compulsory schooling; these attitudes will be affected, at least in part, by the quality and type of teaching to which the pupils are exposed. It was acknowledged that pupils acquire information (and possibly some *mis*understandings) about science from sources outside school, particularly from the media and from influences in, and around, the home. Further work to promote the image of science in schools and to increase its accessibility to the general public is essential to produce a 'scientifically-literate' workforce. The lack of pupils' enthusiasm for a career in science, sometimes followed by an adult mistrust of science and scientists, was linked to the pupils' early experiences of, and the formation of attitudes towards, school-based science.

Some of the various attempts to define 'attitudes' have been briefly discussed in the context of the understanding of social behaviour. Constructivist approaches to teaching and learning in science, as well as some of the criticisms of this theory, were also outlined. Ways in which conflicts in knowledge interact in pupils' minds as well as the link between the strategies adopted by pupils in order to cope with their 'border crossings' and the pupils' formulation of questions about science were discussed.

Although much science is learnt outside the classroom, the content and delivery of the curriculum were likely to be key factors in influencing pupils' attitudes. The need to relate science to pupils' 'life-worlds' and to enable them to 'cross the border' between 'indigenous' and 'school' science was established by the time (in the late 1980s) that proposals were being finalised to adopt a new, compulsory National Curriculum for Science. This new curriculum (Department of Education and Science/Welsh Office, 1989) offered the opportunity to re-think the content and delivery of school science, to make science more relevant to pupils' lives and to improve pupils' attitudes towards the sciences in general. The development of the National Curriculum for Science for use in English and Welsh schools is discussed in more detail in Chapter 2.

Chapter Two:The National Curriculum with special reference to science

Introduction

The first steps to provide a common curriculum[1] for use in state schools in England and Wales were initiated some 40 years ago. Before this time, the Headteachers in state-controlled primary schools would, in consultation with the local education authority (L.E.A.), devise their own curricula, subject to the approval of Her Majesty's Inspectors (H.M.I.s). The "11-plus" examination, taken by pupils in their last year of primary school, determined whether a pupil would proceed to an academically-selective grammar school for at least 5 years and take the General Certificate of Education (G.C.E.) Ordinary ("O") Level examinations at age 16 or, alternatively, to a secondary modern or technical college for at least 4 years (i.e. to age 15). In the secondary modern schools a limited range of G.C.E. "O" level and Royal Society of Arts (R.S.A.) or similar examinations was usually available but more emphasis was usually placed on the practical areas of the curriculum and most children left these schools at age 15 without any formal qualifications. The technical colleges provided a range of practically-based subjects often focusing on the City and Guilds of London Institute, or the Royal Society of Arts (R.S.A.), examinations at the end of the course.

In 1962, in an attempt to consolidate the variety of curricula and examinations on offer, the Schools Council for the Curriculum and Examinations was set up (Schools Council, 1965) to be responsible, *inter alia,* for devising a curriculum to suit a wide range of individual needs and to set common standards of achievement and potential which could be compared by parents, universities and employers. These positive steps towards some radical changes in the school curriculum were closely linked with the plans to increase, from 1970 onwards, the school leaving age[2] for <u>all</u> pupils to age 16. With these objectives in mind, it was recommended (Schools Council, 1965) that any new curricula should therefore cover a five year span and should include some less academically demanding courses.

In 1965, the newly-elected (Labour) government announced its proposals to end academic selection at age 11 and to introduce a comprehensive system of education for all secondary age children (Department of Education and Science, 1965). Almost simultaneously with these ambitious proposals, the Certificate of Secondary Education (C.S.E.) was introduced to supplement the more academically-orientated G.C.E. courses but efforts to speed up the

[1] "Curriculum" was interpreted as 'the organisation and content of the formal teaching programme as defined by the timetable' (Department of Education and Science, 1981b).

[2] Raising of the School Leaving Age (R.O.S.L.A.)

process of comprehensivisation, combined with the significant building and organizational demands of the R.O.S.L.A. policy, further delayed any serious attempts at developing some curriculum uniformity in English and Welsh schools. Although, with a change of Government (to Conservative) in the early 1970s, there were proposals for a significant increase in spending on education (Department of Education and Science, 1972) there was still little emphasis placed on the need for curriculum change.

2.1 "The Great Debate"

With yet another change of Government in 1976, the new (Labour) Prime Minister, James Callaghan, intent on radically changing the education system so as to accommodate the 'white heat of technology', called for "a Great Debate" on education. In response to this, a Green Paper was published (Department of Education and Science, 1977a) which called, *inter alia,* for urgent action on the curriculum up to the age of 16. In many schools, the curriculum was not only overcrowded but it "was not sufficiently matched to life in a modern industrial society" (Department of Education and Science, 1977a, p.11).

However, some of the factors common to successful schools were by now being monitored independently by H.M. Inspectorate. The balance, design, planning and co-ordination of the school curriculum (particularly its relevance to the developing needs and abilities of the pupils), together with the availability of curriculum choice and the willingness of the teachers to accept and extend new ideas, were identified as crucial factors in designating a school as "successful" (Department of Education and Science, 1977b). The patterns being adopted by these "successful" schools therefore began to inform government thinking on the need for more positive moves towards a common core curriculum.

2.2 Proposals for a common 'core' curriculum

2.2.1 Secondary

In order to address the issues raised in the Green paper, as well as the demands of employers, parents and teachers, the H.M.I. Working Party proposed (Department of Education and Science/ Welsh Office, 1977c) that steps should be taken to establish a "protected" or "core" curriculum common to all secondary schools which would occupy up to 75% of the pupils' time and would include English, Mathematics and Science. The new curriculum would introduce pupils, during their years of compulsory schooling, to certain essential 'areas of experience': aesthetic and creative; ethical; linguistic; mathematical; physical; scientific; social and political; and spiritual. It was proposed (Department of Education and Science/ Welsh Office, 1977c) that any curriculum provided for pupils up to age 16 should provide a well thought out and progressive experience in all these areas.

The 'scientific area' was to be concerned especially with observation, prediction (based on hypothesis) and testing/experimentation. These working papers demonstrated a significant step forward in the detailed consideration of the aims and objectives of a national curriculum and how this curriculum would be delivered especially at secondary level.

For over a decade, the increase in pupil numbers generated by the R.O.S.L.A. policy and the major re-organisation of schools due to the policy of comprehensivisation, as well as resistance from teachers (see Fowler, 1988, p.49) had hindered any significant progress towards these recommendations for curriculum change. In 1980, following another change of Government (to Conservative), a consultative paper, "A Framework for the School Curriculum" was issued (Department of Education and Science, 1980a) which stressed the division of responsibility for the school system between central Government and the L.E.A. (which would have responsibility for the curriculum offered in its schools). Because of the current variations in practice between different schools it was now thought appropriate to address the need for curriculum change and, particularly, the introduction of the "core" curriculum which would ensure that all pupils received sufficient grounding in the basic knowledge and skills necessary for them to develop into educated adults. It was proposed that 10 per cent of the timetable per subject should be devoted to the common "core" subjects in the early years of secondary education, increasing to 20 per cent for some subjects e.g. science and modern languages, after the age of 13.

As the teaching content of most of the secondary curricula was examination-driven, the focus had been primarily on the need for a "core" curriculum in the secondary schools. "A View of the Curriculum" (Department of Education and Science, 1980b), a more detailed document also published in 1980 by H.M. Inspectorate, acknowledged the need for a broad curriculum in the secondary sector which should have a substantially larger compulsory element than would be the case in the primary schools.

School science was regarded as important in developing an understanding and appreciation of technology and it was recommended (Department of Education and Science, 1980b, p.16) that "engagement with the processes of science should also be helping to strengthen general powers of observation and reasoning". It was also noted that a requirement that all pupils should sustain a broad programme of science education at least up to age 16 "does not imply identical syllabus content or identical treatment for all nor does it overlook the interests of the future scientist" (Department of Education and Science, 1980b, p.18).

Following a joint curriculum enquiry (Fowler, 1988 p. 67) which brought together contributions from five L.E.A.s and 41 schools on the practical implications of the proposals for school time-tabling and course planning[3], the first proposals for a truly common "core" curriculum of English, mathematics and science (which would take up 75% of the secondary pupils' timetable) were put forward in the "Curriculum 11-16" document (Department of Education and Science, 1981a). The common curriculum would:

- be a broad body of *skills, concepts, attitudes and knowledge*
- be followed by all pupils, at a level appropriate to their ability, up to the age of 16.
- contain eight "areas of experience"[4] listed (alphabetically) as the: *aesthetic and creative, ethical, linguistic, mathematical, physical, scientific, social and political, and the spiritual.*

(Department of Education and Science, 1981a, p.3)

In March 1981, "The School Curriculum" (Department of Education and Science, 1981b) repeated the need for this broad curriculum but stressed that it was for individual schools to "shape the curriculum for each pupil" (Department of Education and Science, 1981b, p.3) and that neither the Government nor the L.E.A.s should specify the detail of what should be taught in the schools. There was also an acknowledgment that account should be taken in schools of the "evolution of educational thinking" (Department of Education and Science, 1981b, p.4) concerning the inclusion into the curriculum of new subjects and subject areas (e.g. environmental education, personal and social education). There was, at last, some acceptance that attempts should be made to devise a school curriculum for the compulsory school years (i.e. up to age 16) which would be more appropriate to a pupil's later employment and adult life.

Although some subject choices would still have to be made at age fourteen[5], it was considered important that some breadth in the curriculum should be maintained right up to the end of compulsory education. This post-14 curriculum should be related to the pupils' "abilities and aspirations" and should contain substantial common elements viz: English, mathematics, science, religious education and physical education so that decisions taken at age 14 did not seriously limit education during the next two years of school education and subsequent career options. In addition, pupils would undertake some study of the

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[3] One of the issues raised was whether the provision of three separate sciences was the most appropriate way to achieve a worthwhile scientific experience for all pupils.

[4] later known as "the eight adjectives"

[5] Pupils up to the age of 14 in all secondary schools would generally have followed a roughly similar programme including English, mathematics, science, history, geography, religious education, art, music, home economics, craft design and technology, physical education and games. Nearly all pupils studied one modern foreign language (and a small minority took up a second modern, or a classical, language).

humanities and most pupils would study a modern language preferably for five, rather than three, years of their secondary education.

2.2.2 *The primary curriculum*

The proposed curriculum for primary schools had received significantly less attention compared with that given to the secondary phase (partly because the "11-plus" examination (see Introduction) was the only examination of any importance in the primary sector. An H.M. Inspectorate survey of primary education in England (Department of Education and Science, 1978), had dismissed concerns that a broad curriculum in primary schools could possibly only be maintained at the expense of the basic skills of reading, writing and mathematics but it was suggested (Department of Education and Science, 1981b) that efforts should be concentrated on the extension of the curriculum for the more able children rather than at the total range of the work. The stated aim (of the primary curriculum) was:

> "to extend children's knowledge of themselves and of the world in which they live, and through greater knowledge to develop skills and concepts, to help them relate to others, and to encourage a proper self-confidence".
>
> (Department of Education and Science/Welsh Office, 1981b, p.10)

It was later recommended (Department of Education and Science, 1984, p.5) that, for primary school pupils, the primary curriculum should "build on their natural enthusiasm.....stimulate their curiosity and teach them to apply it purposefully and usefully". It was hoped that both coherence and progression would be offered to pupils thus facilitating the transfer to secondary school at age 11.

As far as science was concerned, Her Majesty's Inspectors of Schools had reported that, in the 1970s, primary science was badly taught or not taught at all (Harlen et al., 1981 and 1983) and this led to renewed concern that more attention should be devoted to the way science was taught in primary schools. The idea that good scientific activity needed to link to everyday themes so that children could pursue problems that were more important and relevant to them was later stressed in the National Curriculum Council's Report "Science in the Primary Curriculum" (1989). It also needed to be practical and active so that children could "see" what they do and have something tangible to think and talk about.

Despite the wealth of advice and reassurances now available on how the new requirements would work in practice, primary teachers were particularly concerned about having to take on board, possibly for the first time, a rigorous assessment of their pupils' skills, knowledge and understanding. There was considerable concern about the apparent complexity of the procedures with which the primary teachers were now expected to be conversant. As central government began to exercise a greater control over curricular matters, it was recognized that a major obstacle to further improvement in primary science was the poor knowledge of science held by many existing primary teachers (Department of Education and Science, 1985a). Although research has shown (see Chapters 1 and 3) that pupils' early experiences of classroom science and the constructs which they build to explain phenomena are important in developing positive attitudes to science in the secondary school, progress on a common curriculum for primary science continued to lag behind that for secondary science.

2.3 Objectives for a "broad and balanced" curriculum

In 1984, the Secretary of State for Education and Science had called (Department of Education and Science, 1984) for a broad consensus about the "definition of objectives" for the new curriculum (for pupils aged 5 to 16) and four strands were subsequently identified. These were: the objectives of learning at school; the contribution of each main subject area or element; the content of the 5 -16 curriculum as a whole and the objectives for attainment at the end of the primary and secondary phases. The application of knowledge and skills was also an area where attention was needed as well as an element of selectivity:

> "the removal of clutter, for example in the form of knowledge which is less than essential, from many existing syllabuses would help to make room for the practical application of what is learned".
>
> (Department of Education and Science, 1984, p.9)

This element of selectivity went some way towards incorporating earlier comments about the need not only for a *broad* and *balanced* curriculum but also for one that was *relevant* to the perceived needs of the pupils both during, and after, the years of compulsory education. Even in the primary phase it was suggested that the curriculum should give children "some insights into the adult world, including how people earn their living" (Department of Education and Science, 1984, p.5).

The following year, the booklet "Better Schools" (Department of Education and Science, 1985a) summarized the changes in both primary and secondary education which had taken place over the previous thirty years and also detailed the future plans for education in English and Welsh schools; the contentious issues of Attainment Targets (ATs) for areas *not* being examined at the end of compulsory schooling and also for all aspects of the curriculum at the end of the primary phase were also mentioned (Department of Education and Science, 1985a, p.26).

Almost in parallel with the "Better Schools" booklet, "The Curriculum from 5-16" was produced by H.M. Inspectorate (Department of Education and Science, 1985b). This particularly stressed (Department of Education and Science, 1985b, p.5) the need for coherence and progression as well as "unity of purpose" as pupils moved from the primary to the secondary phase. Specific examples of how different experiences could contribute to each of the "eight adjectives"[6] were included. The four "elements of learning" i.e. *knowledge, concepts, skills* and *attitudes* were defined and discussed at some length. Suggestions as to how individual subjects might be developed within this "coherent, broad and balanced" curriculum were outlined. In science, the emphasis would be on "increasing pupils' knowledge and understanding of the natural world and the world as modified by human beings" (Department of Education and Science, 1985b, p.29), developing observation skills, framing hypotheses and devising and conducting experiments as well as considering "real problems" (Department of Education and Science, 1985b, p.30). It was hoped that the curriculum would help pupils "to become better informed about, and competent to judge, the importance of scientific developments upon individuals and society at large" (Department of Education and Science, 1985b, p.32).

By now the importance of a curriculum which was not only *broad* and *balanced,* but one which also showed *relevance, differentiation, continuity* and *progression* from the beginning to the end of compulsory schooling was, at last, very firmly established. The interdependence of the proposed curriculum and the requirements of the examination boards at secondary level meant that further revision of the examination system was, however, needed before the details of any new national curriculum could be confirmed. In 1983, the independent Secondary Examinations Council (S.E.C.) had been set up to supervise examinations taken up to the end of a pupil's secondary schooling (Department of Education and Science, 1985a) and the first examinations for the General Certificate of Secondary Education (G.C.S.E), which was introduced to replace the G.C.E., C.S.E. and other 16+ examinations, was offered in 1988. The new G.C.S.E. put emphasis on "oral and practical skills and course-work, on reasoning and on the application, as well as the acquisition, of knowledge and understanding" (Department of Education and Science/Welsh Office, 1985a, p.30). The Government expressed confidence that the new system would "promote a much needed increase in those practical and other skills which

[6] previously known as "areas of learning" viz: aesthetic and creative, human and social, linguistic and literary, mathematical, moral, physical, scientific, spiritual, together with a new addition, technological.

will be demanded by the future pattern of employment" (Department of Education and Science/Welsh Office, 1985a, p.32).

Throughout the previous decade, there had been much concern about the number, and quality, of scientists and engineers joining the nation's workforce (see Chapter 1). The introduction of a centrally-controlled national curriculum would attempt to bring the education system in England and Wales more into line with European practice and hopefully improve the nation's science base and competitiveness abroad. In 1983, the Technical and Vocational Education Initiative (T.V.E.I), which aimed to offer courses to prepare pupils for work in industry and commerce was introduced (H.M. Inspectors of Schools, 1991). Together with the Government-sponsored 'Microelectronics Programme' (M.E.P) which, *inter alia*, encouraged the use of computers in primary schools (Fowler, 1988, p.103) and aimed to prepare pupils "for a society in which the new technology is commonplace and pervasive" (Department of Education and Science/Welsh Office, 1985a, p.15), these two initiatives led to a shift of emphasis in learning and teaching patterns which were significantly to inform the on-going discussions on curriculum structure and content.

2.4 Proposals for legislation

After some 20 years of seemingly endless discussions, consultations and publications, the (now Conservative) government issued, in 1987, a consultation document entitled: "The National Curriculum 5-16" (Department of Education and Science/Welsh Office, 1987). This was significant in that it was the first time that a Department of Education and Science publication had referred to a "National" Curriculum in its title.

A basic, core curriculum, of English, mathematics and science would be followed by all pupils during their compulsory schooling (i.e. up to age 16) with the majority of time at primary school being given to these three subjects. At secondary level these core subjects would take up about 30-40% of the timetable. The requirements for the core subjects would be more rigorously defined than for the foundation subjects which would be studied up to at least age 14. Attainment Targets (ATs), specified at up to 10 levels of attainment from ages 5 to 16, together with assessment arrangements for these levels of attainment, would be laid down for the three core curriculum subjects.

Programmes of Study (PoS), which specified the essential teaching within each subject area, would also be defined. There would be a set of "foundation" subjects viz: technology, history, geography, art, physical education and music, plus a modern foreign language (secondary level only); religious studies would remain an essential part of the curriculum. Additional subjects, for example, a second foreign language and other, more general subject areas such as health education and information technology, would still be incorporated at a level which would not affect the time allotted to the foundation subjects. A National Curriculum Council (N.C.C.), in England, and a School Examinations and Assessment Council (S.E.A.C.) would be set up (Department of Education and Science/Welsh Office, 1987) to support the legislative details on curriculum assessment and testing, monitoring and inspection.

2.5 The Educational Reform Act (ERA), 1988

Although there was still some disagreement about the balance between, and the objectives of, the different curricular elements, the legislation for a 'National Curriculum' was consolidated in the Education Reform Act (1988). This provided for the establishment of a National Curriculum containing core and foundation subjects to be taught to all pupils of compulsory school age in state schools. For each individual subject area, e.g. science, there would be appropriate Attainment Targets, Programmes of Study and assessment arrangements and these requirements would be controlled through the subordinate legislation of Statutory Instruments.

2.6 The National Curriculum for Science

In June 1988, on the basis of the policy statement for pupils aged 5 to 16 (Department of Education and Science/Welsh Office, 1985c) and the advice from organisations such as the Association for Science Education, the Science Working Group under Prof. J. J. Thompson had made their recommendations (Department of Education and Science/Welsh Office, 1988) for the National Curriculum for Science. It was proposed (Department of Education and Science/Welsh Office, 1988, pp. viii-xi) that there should be 22 Attainment Targets[7] (ATs) for all pupils aged 11 to 16, and 17 ATs for pupils aged 7 to 11. It was proposed that the ATs be grouped together under 4 Profile Components (PCs) covering: knowledge and understanding; skills of scientific investigation; skills of communication; and awareness of the impact of science on society - see Appendix 2.1.

The Working Group's proposals for the Programmes of Study[8] attempted to demonstrate "how the range of content, skills and processes, reflected in the attainment targets, (could)

[7] "clear objectives for the knowledge, skills, understanding and aptitude which pupils of different abilities and maturity should be expected to have acquired at or near certain ages" (Department of Education and Science/Welsh Office, 1988, p.1).

[8] "the essential content which needs to be covered to enable pupils to reach or surpass the attainment targets" (Department of Education and Science/Welsh Office, 1988, p.1).

be integrated into a coherent framework". The group suggested (Department of Education and Science/Welsh Office, 1988, p.ix) that, in the secondary phase[9], the time allocated to science should be no more than 20% of curriculum time but this percentage could be less if more time was spent on science in the earlier years. The Group welcomed the Government's assurance that the detailed National Curriculum requirements would "not be set in concrete" and recommended that the N.C.C. and the Curriculum Council for Wales "establish machinery an early date to keep the new arrangements for science under review" (Department of Education and Science/Welsh Office, 1988, p.x).

Within the ATs were Levels of Attainment, together with Statements of Attainment indicating, at the various levels, what each pupil should know, understand and be able to do, at the end of Key Stages 1, 2, 3 and 4 (i.e. at ages 7, 11, 14 and 16 respectively).

Table 2.1: Range of levels of attainment at Key Stages 1 to 4

Key Stage	Expected range of levels of attainment
1 (5-7 years)	1 - 3
2 (7-11 years)	3 - 5
3 (11-14 years)	4 - 7
4 (14-16 years)	4 - 10

(Department of Education and Science/Welsh Office, 1988, p.14)

Commenting on the first proposals, the Secretaries of State suggested (Department of Education/Welsh Office, 1988, p.iii) that "developing pupils' understanding of the scientific method should go hand in hand with developing their knowledge and understanding of scientific facts and theories"; it was also recommended (Department of Education/Welsh Office, 1988, p.iv) that the proposals should be modified to allow for a reduction in the number of PCs to three or, ideally two.

The teaching profession still remained concerned about the prescriptive nature of the proposed science curriculum and these concerns re-iterated the comments of Ormerod and Duckworth (1975) who some 15 years earlier had concluded:

> "....there is no such thing as a single 'best' curriculum.......the more prescriptive a syllabus or curriculum becomes, either in its sequence of topics or even in its precisely defined curriculum objectives, the less room there is for the individual teacher to manoeuvre in meeting the needs of the individual pupils"
>
> (Ormerod and Duckworth, 1975, p.106)

One of the many issues to be resolved was the amount of curriculum time which could realistically be devoted to science bearing in mind the demands on curriculum time of

[9] now Years 10 (ages 14/15) and 11 (ages 15/16).

other subjects. The recommendation of the Working Group (Department of Education/Welsh Office, 1988, p.v) was that "Model A, a "balanced" science course based on the Integrated Science projects of the 1970s, would be taken by the majority of pupils in the 11 to 16 age range, and this would take up at least one-sixth of overall curriculum time. The course, known as "Double Award" Science, would cover the three sciences of chemistry, physics and biology and lead to two G.C.S.E. certificates. (After the end of KS3 a maximum of 20% of available curriculum time could be used by those pupils who wished to study the three sciences in greater depth with a view to gaining three G.C.S.E. certificates). For some pupils, the introduction of a single award in "balanced science" ("Model B") would be offered (Department of Education/Welsh Office, 1988, p.v) - it was felt that this might be appropriate for those pupils for whom the use of 20% of curriculum time on Science was not realistic in view of their Special Educational Needs or because of the time committed to other subject areas.

It had been stressed much earlier (Department of Education and Science, 1981b), that the new curriculum would also need to take account of gender issues, particularly in the context of the science curriculum. Many studies (see Chapter 3) carried out before the introduction of the National Curriculum had shown that girls were less likely than boys to take up the sciences and one of the main objectives of the new curriculum was, therefore, to remedy this imbalance. However, despite all the recommendations about the essential ingredients of a new curriculum for science with its emphasis on assessment and attainment targets, little mention was made of assessing pupils' *attitudes* towards science.

Reporting on evidence submitted to the Science Working Party, it was noted:

> "Although the emphasis we placed on developing scientific attitudes in children was welcomed, many advised that separate assessment was inappropriate. This was not to imply that attitudes were not important, but that a more fruitful approach would be to concentrate on those attributes concerned with what pupils actually did."
>
> (Department of Education and Science/Welsh Office, 1988, p.122).

There was, however, a (perhaps realistic) comment in the N.C.C.'s Consultation Report on Science (National Curriculum Council, 1989), that:

> "Nevertheless, it is likely that the problems of low expectations of many girls, particularly in physical science, will remain. The design of courses, the use of materials which avoid sex stereotyping and the involvement of girls' own perspectives on problems, issues and ideas are important factors in increasing the involvement of girls in physical science".
>
> (National Curriculum Council, 1989, pp. A9-A10).

As far as science teachers were concerned, it was intended that, as with other subjects, they would develop their own teaching schemes within the proposed framework but that several criteria[10], such as whether the scheme encouraged pupils to apply scientific ideas to real-life problems (including those which required a design and technological solution), should be used to select the learning experiences most appropriate for the pupils (National Curriculum Council, 1989).

By early 1989 the N.C.C. had completed its statutory consultation in Science (National Curriculum Council, 1989) and, by March, the Order for Science together with the associated document "Science in the National Curriculum" (Department of Education and Science/ Welsh Office, 1989) were published. It was anticipated that Science at Key Stage 1 (KS1) and Key Stage 3 (KS3) would be introduced by the autumn of 1989, with the Science curricula for KS2 to follow in 1990 (and the first year of KS4 in 1992).

In January 1991, in the light of the protestations on the complexity of the (now statutory) National Curriculum and the consequent increase in teachers' workloads, the Secretary of State for Education and Science announced (see Department of Education and Science/Welsh Office, 1991) an urgent review of the attainment targets in science. It was felt that the structure of the 17 ATs was "proving an obstacle to manageable and sound testing and intelligible reporting to parents" and that the "consistency and continuity" of G.C.S.E. standards was at risk unless the number of ATs was reduced (National Curriculum Council, 1991, p.8). Proposals for the revised ATs and PoSs were published in May 1991 (Department of Education and Science/Welsh Office, 1991) and, following the statutory consultation procedure, a new Order for Science[11] was laid before Parliament (in parallel with a similar document for mathematics) and came into force on 1st August 1992.

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[10] see Appendix 2.2

[11] Statutory Instrument 1991, No. 2897

The revised Science curriculum (Department of Education and Science/Welsh Office, 1991) now contained just 4 ATs and Statements of Attainment. There were changes in the weightings of these ATs which were now grouped as Experimental and Investigative Science (a practical assessment), Life and Living Processes (biology), Materials and their Properties (chemistry) and Physical Processes (physics); an area of overlap between the science and the geography curricula was removed and examples linked to the Statements of Attainment were included. Provision was made in the revised curriculum for a narrower range of ATs to form the basis of the less intensive Single Science course, "Model B", which could be followed by some pupils after KS3. There were modifications to the Programmes of Study but only minor curriculum changes and, to the relief of many teachers, little alteration to existing schemes of work. It was anticipated that the teacher assessment and the results of the national tests would be given equal weighting in the future thus meeting some of the teachers' objections to the manner in which the new curriculum appeared to devalue their professional judgement.

2.7 More changes: The Dearing Report

Almost from the start, it became clear that the new National Curriculum with its enormously increased workload of assessment and the need to respond quickly to so many changes, meant that the requirements of the Act were almost unworkable in their existing form. With yet more protests from the teaching profession about the prescriptiveness of the new Curriculum which teachers felt undermined their professionalism, Ron (now Sir Ron) Dearing was asked by the Secretary of State for Education[12] and the Secretary of State for Wales[13] to chair an Advisory Group with the task of identifying the problems and making recommendations for remedying the situation (Dearing, 1993).

> "One of the lessons to be learned from the past is that of misjudging the manageability of change"
>
> (Dearing Report, 1993, p.6).

[12] Rt. Hon. John Patten MP
[13] Rt. Hon. John Redwood MP

Not surprisingly, one of the main problems identified was that, in an attempt to avoid ambiguity, the rigid fashion in which the requirements of the Act were set out were 'unacceptably constricting' to the teaching profession (Dearing, 1993, p.5). Other problems arose because the Working Groups for each Order (subject area) had not considered the relationship of their specialist subject within the whole curriculum and this had resulted in some content overlap between the different subject areas (see Dearing, 1993). Also the attempts, for most subjects, to rank knowledge and skills hierarchically from ages 5 to 16 on a 10-level scale had caused many problems.

The recommendations of the Dearing report were, therefore, to revise each Curriculum Order[14] so that it contained a statutory core which *must* be taught, together with optional studies which could be taught at the teacher's discretion. The importance of Science, together with English and Mathematics in the new curriculum meant that the statutory core for these subjects would be larger than that of the other subject areas. It was also suggested that the number of Statements of Attainment[15] on which teachers were required to make judgements should also be reduced. One of the other major issues which needed to be addressed was whether there should be any modification of the 14 to 16 curriculum in order to provide a smoother transition to post-16 study. Another recommendation was that national testing should be limited for the next 3 years to the core subjects of English, Mathematics and Science (and in 1994 the tests should be limited to KS2 and KS3 only). It was intended that one of the main outcomes of the review would be to "provide a large measure of stability in the curriculum for the next two years" (Dearing, 1993, p.1).

In his conclusions, Ron Dearing commented: "preliminary work should begin on the approach to slimming down the curriculum and on reducing greatly the present statements of attainment." It was acknowledged (Dearing, 1993, para. 2.43) that the pace of change had been "extremely demanding" and that the administrative burden in the classroom, together with the late provision of information needed for curriculum planning, had exacerbated the situation.

Following consultation on the recommendations of the final Dearing Report (1993), proposals for yet another revision of the science curriculum were put forward in May

[14] The Mathematics and Science Curriculum Orders had already been streamlined by the time the Dearing Interim report was printed.

[15] Statements of Attainment attempt to define what a pupil must know, understand and be able to do at each level.

1994 (School Curriculum and Assessment Authority, 1994) and new orders[16] were drawn up (Department for Education and Science/Welsh Office, 1995) which were to come into force on 1st August 1995 (for all year groups in Key Stages 1-3). New G.C.S.E. syllabi, reflecting the revised Science curriculum, would be introduced for KS4 courses beginning, for Year 10, in August 1996 (and for other KS4 pupils in August 1997). The ten-level scale was not now to be used for assessment after KS3; at this level separate attainment descriptions would be devised, related to grades at G.C.S.E. level and their equivalents. At the end of Key Stages 1, 2, and 3, the standards of pupils' performance would also be set out in 8 (instead of 10) descriptions of increasing difficulty, with an additional description above 8 for 'exceptional performance'.

After almost two decades of protracted discussion on the curriculum for science, it appeared that some of the criticisms of the proposed 'broad and balanced' curriculum which aimed to have relevance and continuity for pupils aged 5 to 16 had, at last, been resolved. However, many of the objections to the original proposals had not been addressed and there were still criticisms, for example those of Millar et al. (1998), that the science curriculum appeared to represent 'pure' science, or the 'knowledge' of science, rather than how it related to events or why it was important.

2.8 "Beyond 2000"

The Association for Science Education (ASE) had been closely involved in the protracted discussions on curriculum development and, in 1998, the Association produced a report "Science Education 2000+" (see McCune, 1998) which set out the recommendations as to how the curriculum for science might be made more appropriate for the 21st century. These recommendations inspired the report of a seminar series, "Beyond 2000: Science education for the future", funded by the Nuffield Foundation (Millar and Osborne, 1998) which included 10 recommendations for further changes in the science curriculum. The key issues concerned the nature of the curriculum itself and, specifically, its lack of attention to 'ideas about science'. It was felt that a greater awareness and understanding of scientific ideas would encourage a greater engagement with, and critical analysis of, contemporary scientific issues reported in the media.

Other concerns were the continuing failure of school science, particularly at secondary level, to sustain and develop the 'sense of wonder and curiosity' about the natural world and the lack of relevance to teenagers' interests. It was argued that the science curriculum would benefit from being presented as a series of 'explanatory stories' which would

[16] Statutory Instrument 1995, no. 53.

emphasise that the understanding of science was based, not on individual concepts, but on interwoven groups of ideas. The post-14 curriculum, particularly, needed to have a greater range and diversity to accommodate the interests of adolescents; it also needed to differentiate between those elements designed to enhance 'scientific literacy' (about 10% of the total curriculum time) for *all* pupils, and those which were appropriate for further development by those pupils wishing to opt for science post-16.

The substance of the recommendations of the Report were approved, by the Qualifications and Curriculum Authority (Q.C.A.) and published in 1999 (Qualifications and Curriculum Authority, 1999). The new syllabi were drafted and made available to schools during 2000 with a view to them being put in place from September 2001 (Department for Education and Employment/Qualifications and Curriculum Authority, 1999). Although there were minimal changes to the curriculum content, probably the most significant change was the alteration to the practical investigation (Sc1), to allow for the integration of a new Sc0 "Ideas and Evidence" component as proposed in the "Beyond 2000" Report (Millar and Osborne, 1998).

The criticisms continued to flow. Russell (1999) maintained that the Q.C.A. had ignored the main thrust of the group's report and that little attempt had been made to address the serious weaknesses identified in the Report:

> "........Liberal notions of 'flexible', 'self-fulfilment', 'appropriate and relevant', and 'being responsive' to 'local priorities' and 'changing needs of pupils' are buried under the statutory heap of prescribed content. There seems to be *no* flexibility, *no* option to localise, and *no* opportunity to be responsive to pupils' needs by increasing the relevance and appropriateness of the content"
>
> (Russell, 1999, p.13)

One of the recommendations of the Dearing Review of Qualifications for 16 to 19-year - olds (Dearing, 1996) was that a new Advanced Subsidiary (AS) syllabus in "Science for Public Understanding" should be developed by the Assessment and Qualifications Alliance (A.Q.A.) as part of the Government's plans to broaden the choices available to pupils within this age group. The AS in "Science for Public Understanding" was piloted in schools in 2000 and was offered as an AS level examination from September 2001. The declared purpose was to give students greater

- *understanding of the science which underpins everyday choices and decisions;*
- *confidence to read and discuss media reports of issues involving science and technology;*
- *appreciation of the impact of scientific ideas on the way we think and act.*

Any further curriculum development post-16 will necessarily influence thoughts on further changes during the earlier years of compulsory schooling and in September 2002 the KS3 strategy for science, which aimed to support schools in their attempts to meet national targets for pupils' achievements in the National Curriculum tests at the end of Key Stage 3, was implemented (Department for Education and Skills, 2002).

2.9 Comment

Relatively little research has examined curricular experiences from the pupils' perspectives but since the fieldwork for this study was completed, the NFER[17] has conducted a research review (Lord and Harland, 2000)[18] on pupils' experiences and perspectives of the National Curriculum. The authors noted that the type of research now being undertaken was shifting from the 'ranking and rating' of pupils' perspectives of various subjects to those which included investigations of the pupils' voice *per se* and the use of the pupils' voice in effecting changes in learning and teaching.

It is acknowledged that many factors, other than the content and delivery of the science curriculum, may influence pupils' attitudes to science and the main objectives of this study were to examine pupils' attitudes to science, particularly with respect to gender issues, following exposure to the first National Curriculum in England and Wales and to compare the findings with those responses, particularly those of a qualitative nature, reported in the literature prior to the inception of a statutory curriculum.

The research questions to be answered are whether pupils exposed to the (much-amended) National Curriculum, with its emphasis on 'relevance, differentiation, continuity and progression' (see section 2.3), would demonstrate more positive attitudes to science in the early secondary school years compared with those reported in the literature of pupils who had not been exposed to the new, compulsory curriculum. Would girls now show more positive attitudes towards the physical sciences and, ultimately, would more pupils express an interest in science post-16 and consider scientifically-orientated careers?

The literature review which follows (Chapter 3) was conducted in order to identify the main areas of research, including the attitude measures used, in the pre-National Curriculum era so that an appropriate methodology for this research study could be defined (see Chapter 4).

[17] National Foundation for Educational Research
[18] updated in March 2001

Chapter Two: The National Curriculum with special reference to science

2.10 Summary

Starting from research in the early 1960s, this Chapter summarised the thinking behind the numerous attempts to develop a 'broad and balanced' National Curriculum for state schools in England and Wales. The examination-driven secondary curriculum was given priority and recommendations for the primary curriculum followed. The difficulties experienced, particularly by teachers, in managing several simultaneous and inter-related changes in education policy (e.g. the raising of the school leaving age, the move towards comprehensivisation and the changes in the examination system) were highlighted.

The development, within the National Curriculum framework, of a National Curriculum for Science (designated as core curriculum subject for pupils aged 5-16) was outlined, together with a resume of the changes which have taken place since the fieldwork for this longitudinal study was initiated. Some recent comments on how the National Curriculum for Science might be made more relevant and appropriate for the 21st century were briefly discussed.

Chapter Three: Review of the literature on pupils' attitudes to science

Introduction

The initial examination of the literature (Chapter 1) suggested that attitudes, including those to science, are formed at an early age. Although the focus of this study concerned the attitudes of lower secondary school pupils, it was important to consider the literature on pupils' attitudes in the primary phase as well as after transfer into the secondary phase. Personal observations suggested that the proposed study should investigate pupils' attitudes, with respect to gender, to both the physical and biological sciences.

This literature review therefore aimed to identify the nature, and duration, of studies on attitudes to school science carried out prior to the inception of the National Curriculum (Chapter 2) and to note:

1. which measures, or criteria, were used to assess pupils' attitudes to school science;
2. whether the studies covered the biological and the physical sciences separately;
3. whether they were undertaken in the primary or secondary phases or both

and 4. the coverage, if any, of "out-of-school" factors such as the pupils' interests and activities, home or parental factors.

Initially, Ormerod and Duckworth's (1975) synopsis of research on pupils' attitudes to science, the post-graduate theses of Abdou[1] (1984), Hewison[2] (1982) and Smail[3] (1984a) and three reports on attitudes to science, published in the latter half of the 1980s (Kelly, 1986; Department of Education and Science, 1986 and Keys, 1987[4]) were examined in some detail (see 3.1.3). Comments of some research literature published during the 1990s, together with some findings published after the initiation of the fieldwork for this study, are included at appropriate points in the text (see also Chapter 10). Within the general framework of the review a wide range of issues (see 3.2 to 3.4) which had attracted research because of their possible links with pupils' attitudes to science were identified.

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[1] "Attitudes to science, scientific interests and scientific attitudes of 100 pupils aged 13 and 15 in secondary schools in South Wales".
[2] "Attitudes to science of pupils aged 10-13 in middle and high schools".
[3] "Factors affecting girls' interest in science on entry to secondary education".
[4] The findings of the Third International Mathematics and Science Study were published in 1997 (Harris et al., 1997 and Keys et al., 1997).

3.1 Primary and secondary phases and transfer

3.1.1 The primary phase

Hewison commented (1982, p.197) on the paucity, at that time, of longitudinal studies on pupils' attitude changes, particularly covering the primary years. The focus of much of the early research literature was on the gender differences in attitudes to the biological, and physical, sciences in the secondary phase and much less had been published (Hodson and Freeman, 1983 and Mortimore et al., 1988) by the end of the 1980s which was relevant to the primary phase. Haladyna et al. (1982) noted a decline in attitudes to science from age 9 onwards and noted that this was associated with the pupils' increasingly negative attitudes towards school itself.

Although Harlen et al. (1984) noted that, in the 1982 survey of primary schools, 95% of English schools were including science-based work in the curriculum for 10 to 11 year olds, there was relatively little interest until the 1990s to enquire into primary pupils' attitudes to science. Science was not a significant part of the primary school curriculum until a national system of assessment was developed in order to deliver the National Curriculum (see Chapter 2) and provision was made for INSET courses in science for primary teachers (see Department of Education and Science, 1985a). There was relatively little literature which compared pupils' attitudes to science, particularly in the primary phase, with those to other subject areas.

During the course of a more recent study (Pell and Jarvis, 2001) on the effect of primary teachers' competence in science and the primary pupils' attitudes to the subject, the authors noted that practical science[5] and English were regarded with more enthusiasm than mathematics but writing in science books was not popular (particularly with the boys). The higher ability girls were found to be more likely to have positive attitudes to reading, using the computer and doing science experiments; the more able boys were more likely to enjoy reading and mathematics.

At primary level, gender differences in attitudes to science were observed by Harlen et al. (1981) who noted that Year 6 girls performed better than the boys on science tasks which involved recording and presenting data. More recently Pell and Jarvis (2001), in their examination of factors underlying primary pupils' attitudes to science, noted that the pupils' enthusiasm for science at the start of their schooling, was not generally outweighed by any perceptions of its difficulty, any negative views of the difficulties were 'subsumed'

[5] Pollard et al. (1994) reported that science was one of the least liked areas of the primary curriculum.

because of the novel experience and the girls seemed to come to terms with it more quickly than did the boys. In their middle primary years, the girls may be 'weighing up' science but, by Year 5, there were strong negative correlations between the girls' enthusiasm for science and its perceived difficulty. Once the initial enthusiasm for science had worn off in Year 3, the boys' attitudes were less clear and, by Year 6, the boys' enthusiasm for science did not seem to be influenced significantly by its perceived difficulty.

The girls' enthusiasm for being involved in science (either inside or outside school) declined more than that of the boys and the authors suggested that, as the pupils perceived that science was getting less difficult, they began to lose their enthusiasm and more 'intellectual rigour' might be needed to restore their enthusiasm for it.

3.1.2 Primary-secondary transfer

Observations on the change in attitudes towards a specific subject area need to be placed in the context of the educational experience as a whole (see Youngman and Lunzer, 1977; Jennings and Hargreaves, 1981; Short, 1992 and Taylor, 1994).

Despite suggestions (Ormerod and Duckworth, 1975; Smail, 1984a and Short and Carrington, 1989) that attitudes are formed early, there has been little relevant recent research on pupils' attitudes to science which has covered the years immediately before, and after, transfer between primary and secondary phases at age 11.

A study by Hewison (1982) was conducted in an area where the pupils attended middle and high schools and transfer to high school occurred at age 12 to13. At that time, there was some concern that, in the middle-high school system, the 'option choices' (i.e. subjects to be studied for the two years prior to G.C.E. examinations) occurred after only one term in the high school and these choices might be significantly influenced by the attitudes fixed in the previous (middle) school. Sixty statements aimed to elicit agreement/disagreement responses on a 5-point scale to factors[6] believed to be important in determining pupils' overall attitude to science were issued to pupils in July 1978. The pupils were in the third and fourth (last) year of a middle school (i.e. ages approximately 11 and 12 respectively). The following year the same statements were issued to all the fourth year pupils (i.e. the previous year's 3rd year) and to half the pupils in the first year of a high school.

The girls' attitudes deteriorated during the last two years of the middle school but no deterioration was detected in the girls' attitudes to science during their first year at high

[6] including school science lessons, 'scientists', science outside school etc.

school. There was, however, no evidence that the boys' attitudes changed over the 3-year period and Hewison queried whether age 13 was a critical point for the stabilisation of girls' attitudes to science. She also commented that many of the 13-year-olds were still at the 'concrete' stage of their development and it was possible that they were being presented with work which was too abstract in nature. Ausubel et al. (1978) had emphasised that learning should be meaningful and that work presented to secondary school pupils should be at an appropriate level and should build on the previous learning in the primary phase.

The longitudinal study of Measor and Woods (1984) which is relevant to this research study was initiated in 1979 and concerned the attitudes and expectations of children, with particular respect to gender issues, between the primary and secondary phases. Although the focus was not primarily on attitudes to science, their observations provided some useful insights into young people's attitudes to science on transfer. Their emphasis was on the "annual cycle of myth recitals" which prepared the pupil emotionally as well as socially, for the new world of the upper school.

> "we saw a died squid in a bottle...........the best bit was when two boys about 14 or 15 were dissecting a rat. They had pinned its legs, feet and tail down........"
>
> boy's comments on transfer to secondary school
> (Measor and Woods, 1984, p.24)

By the end of the first year the boys had discovered that the surface myths were largely untrue but they still continued with their cycle of story-telling. Unlike the boys (see above) the girls showed an early distaste for certain aspects of science:

> "One thing I don't want to do is cut up a rat. I don't think that's nice 'cos sometimes they do it alive so that you can see the heartbeat......"
>
> girl's comments on transfer to secondary school
> (Measor and Woods, 1984, p.26)

Measor and Woods' study concentrated, *inter alia*, on the age of transfer[7], induction schemes, the nature of adolescence and its effects on formal school culture. The authors pointed out that the age of transfer between a middle and upper school came at a particularly awkward time in the children's development; the children were undergoing a pre-pubertal growth spurt and they were also becoming increasingly self-conscious.

[7] transfer between middle and upper school was at age 12.

In 1985 it was recommended (Department of Education and Science, 1985b) that the transfer from primary to secondary education should be made as smooth as possible[8] and that the secondary school should try to ensure that the children's "personal confidence and sense of well-being are protected, and that their learning continues with the minimum of disruption" (Department of Education and Science, 1985b, p.49, para.130). (With the inception of the National Curriculum and the introduction of Key Stage tests at ages 7, 11, 14 and 16, the two-tier system has generally been seen as more appropriate to the assessment of pupils' learning).

Recent research at Homerton College, Cambridge has focussed on the impact of transitions[9] and transfer[10] (after Year 6, about age 11) on pupils' performance and attitudes (Galton et al., 2002). Expressing concern about the group of pupils (mainly boys) who were making satisfactory academic progress but who were being 'turned off' school and becoming demotivated, the authors commented on the need for preparing pupils for the 'social upheaval of transfer' and the need for a better balance between academic and social concerns (both at transfer and at various transition points). Noting that engagement[11] in science lessons fell from 60% of the pupils pre-transfer to 34% after transfer, the authors commented specifically on the 'dip' in attitudes to science observed in Year 8 (this is discussed in more detail in Chapter 10).

3.1.3 The secondary years

In her study of some of the reasons which might influence 'option choices' at age 14, Hewison (1982) had noted that the quality and presentation of subjects in the lower forms of secondary school were extremely important in determining the eventual choice of subjects at age 14. Three major research projects conducted in the latter half of the 1980s (Department of Education and Science, 1986; Kelly, 1986 and Keys, 1987) explored some of the other possible influences on the uptake, particularly by the girls, of science beyond the 'option choices' stage.

3.1.3(i) The Girls into Science and Technology (G.I.S.T.) project: Kelly, 1986

This longitudinal survey was undertaken as part of an action research project in 10 comprehensive schools in the Manchester area. The schools were drawn from a wide

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8 See also Marshall (1988) pp.39-53.
9 from one year to another
10 from one school to another
11 'Fully engaged' was regarded as being on task for 75% of the lesson.

variety of socio-economic catchment areas and were 'reasonably representative' of urban comprehensive schools (Kelly 1986, p.400).

The aims were to investigate some of the reasons for the reported underachievement by girls in science and technology and, by using certain intervention strategies in eight of the 'action' schools (including visits from women scientists and the use of curriculum materials more appropriate to girls' interests), to remedy this underachievement.

The attitudes of 1300 pupils to various aspects of science were sought on arrival at comprehensive school in September 1980. The children completed a series of tests (administered by teachers in normal classroom situations) which covered, *inter alia,* the pupils' attitudes to science, cognitive skills and sex stereotyping. The second tests, some of which were identical to those issued in 1980, were administered two and a half years later (between March and May 1983).

The impetus for the G.I.S.T. study had come from the women's movement of the 1960s and 1970s to secure equal opportunities legislation; it was the first major study to address the problem of gender stereotyping in English schools. The hypothesis of the study was that under-achievement by girls in science and technology was, in part, socially constructed by the nature of the school rather than by any motivational element. This study gave rise to the idea of 'girl-friendly'[12] science (i.e. science which would appeal equally to both boys and girls).

The data derived from the G.I.S.T. study were analysed in depth (Kelly et al., 1981; Kelly, et al., 1984; Kelly and Smail, 1986 and Smail and Kelly, 1984a, 1984b) and the conclusions have formed a significant part of the pre-National Curriculum literature on pupils' attitudes to science. The key issues which are relevant to this thesis are given in Appendix 3.1.

3.1.3(ii) The Assessment of Performance Unit (A.P.U.) studies: Department of Education and Science, 1986.

Between 1980 and 1984, the A.P.U. science monitoring programme conducted five annual surveys (using short-answer, extended response and multiple choice formats) of about 5,000 pupils at each of three ages (11, 13 and 15) in England, Wales and Northern Ireland.

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[12] the various strategies adopted (e.g. changing patterns of classroom interaction, single-sex grouping etc.) were discussed in detail by Whyte et al. (1985).

Continuing concern about girls' lack of interest in science, particularly in the physical sciences, was the main focus of the A.P.U. studies; relatively few girls, in this pre-National Curriculum environment, were electing to study physics beyond age 14.

> "...while boys and girls share similarly positive attitudes towards science (and maths) as young children, for girls more than boys these attitudes change during the secondary school to become quite negative."
>
> (Department of Education and Science, 1986, p. 6)

The assessment framework for the A.P.U. studies was deliberately process-orientated and included sub-categories such as 'Planning parts of investigations' and 'Using measuring instruments' etc. The pupils were asked about their "out-of-school" experiences in using particular measuring instruments (thermometers, weighing scales etc.) and, in the 1984 survey, additional information was collected about pupils' scientific interests, out-of-school hobbies and activities and job aspirations. Early interest/enthusiasm for science was assessed by questioning whether the children would like to 'do more' of each of the named activities. Key findings, relevant to the subject of this thesis, are given in Appendix 3.2.

3.1.3(iii) The Second[13] International Science Study: Keys, 1987

A wide-ranging analysis of several aspects of science education in the pre-National Curriculum years was compiled by Wendy Keys in 1987. The data were collected in 1984 by questionnaires from 10-year-old and 14-year-old pupils (*n=3802* and *n=3176* respectively), as well as pupils in their last year of school and at Colleges of Further Education, as part of the Second International Science Study carried out under the auspices of the International Association for the Evaluation of Educational Achievement (I.E.A.). Standardised tests were used to collect data on pupils' achievement as well as on a wide range of "out-of-school" and "in-school" factors.

The overall aims of the study (Keys, 1987) were to identify factors, particularly those associated with the nature of the science curriculum[14], which might explain differences in the output of science education programmes between, and within, the 26 countries involved in the study. In England, about 24 students from each of 181 schools (134 in the Third study) participated in the study; pupils in the upper primary (age 9.9 to 10.8 during

[13] The first study took place during 1970-71, see Comber and Keeves (1973); the findings of the Third International Mathematics and Science Study in 1995 (Keys et al., 1997) were published after the initiation of the fieldwork for the research study.

[14] Pressure to develop a broader, less specialised science curriculum had resulted in the setting up, in 1981, of the Secondary Science Curriculum Review (S.S.C.R.) to initiate curriculum development.

the period of testing) and the lower secondary phase (age 13.9 to 14.8) were involved as well as pupils in their final year at school (and pre-tertiary students at colleges of further education). Multiple choice questions, covering the pupils themselves, their home background, their attitudes to mathematics and science and their perceptions of mathematics and science lessons, were used.

The declared purpose of the study was to provide a "broad brush" (Keys, 1987, p.3) description of science in schools as perceived by both the students and their science teachers and to compare the findings with the results of the first study conducted in the 1970s (Comber and Keeves, 1973). The study also aimed to complement the A.P.U. surveys (Department of Education and Science, 1986) by examining factors associated with favourable attitudes towards science and, noting any gender differences, to investigate the association between these attitudes and data on the students' achievement (as measured by standardised tests) and also on a wide range of home, student and "in-school" measures (e.g. teaching and learning). The pupils' interest in science compared with other subject areas was noted as well as the students' attitudes towards various aspects of science including the importance of science in society, the 'facility' or easiness of science, career interest in science and liking for school.

For each age group, a composite measure was derived which represented the social, cultural and educational level of the students' homes. Factors relating not only to the pupils but to the social and educational background of the home (parents' occupational and educational levels and liking for science) and the school and classroom environment including teaching features (i.e. the "in-school" factors), were also taken into account.

Although no assessment was made of the parental contribution to the pupils' "out-of-school" science-orientated activities, the study took account of some of the pupils' "out-of-school" and home factors. Multiple regression analyses were used to compare the relative strengths of the "in-school" and home ("out-of-school") factors. Other key findings of relevance to the proposed study are given in Appendix 3.3.

3.2 "In-school" factors

3.2.1 Interest in, and enjoyment of, school science

Referring to the findings of the Dainton Report (Council for Scientific Policy, 1968) on pupils' apparent lack of interest in science and the decision whether to undertake study of the sciences beyond age 14, Ormerod and Duckworth (1975) concluded that this lack of interest was almost definitely related to the pupils' attitudes to the subject itself and to the manner in which this subject area was taught within the school. They commented that:

> "interest in science ripens at an earlier age than interest in any other major study area."
>
> (Ormerod and Duckworth, 1975, p.4)

These researchers, as well as Abdou (1984), Smail and Kelly (1984b), Doherty and Dawe (1985) and Johnson (1987) observed that pupils' interest[15] in science declined as they progressed through secondary school. Woolnough (1996) noted that, between Years 7 and 11, the percentage of pupils who recorded negative attitudes to their science lessons increased from 23% to 52% and research studies published after the initiation of this research study (Council for Science and Technology, 1999; Simon, 2000; Bricheno, 2001 and Murphy and Beggs, 2003) have shown similar trends.

Smail (1984a) suggested that children who later specialised in science, developed an interest in the subject before the start of secondary school and commented (Smail, 1984a, p.9) on earlier research which concluded that much of the effort to encourage older pupils (in their late teens) to study science was "a waste of time." The early age at which attitudes, particularly attitudes to science, are formed is an important strand throughout the research literature and the need to make science lessons interesting was emphasised in several publications in the mid-1980s (Secondary Science Curriculum Review, 1983; Department of Education and Science/Welsh Office, 1985c, d and e).

Concerning primary school pupils, the findings of the Third International Mathematics and Science Survey (Harris et al., 1997) suggested that 79% of the Year 5 pupils in England *strongly agreed, or agreed*, with the statement "I enjoy learning science" (Harris et al., 1997, p.84) i.e. they were demonstrating very positive attitudes. However, in a more recent (cross-sectional) study conducted by Miller et al. (1999), the percentage of secondary school pupils who responded positively to questions about their enjoyment of science was considerably less. Just under half of the 6,000 pupils[16] looked forward to Science (and English) lessons and 40% of the pupils[17] agreed that science (and English) were 'fun'.

The relative popularity of science (compared with English, mathematics and technology) for some KS3 pupils *(n=4023)* in Wales was reported by Hendley et al. (1995). Science

[15] defined by Smail (1984a) as 'the extent to which children seek more knowledge about the subject'.
[16] aged 11-16 in 9 secondary schools
[17] 27% thought mathematics was 'fun'.

was the least popular and this was confirmed by a later study based on interviews with 190 pupils (Hendley et al., 1996). When the pupils were asked which three subjects they liked best, science was ranked 5th (out of 12); when asked which subjects the pupils liked least, science was recorded as the most disliked, particularly by the boys.

3.2.1(i) Strategies for teaching and learning

In 1992, Myers and Fouts reported that the most positive attitudes were related to the use of a wide range of teaching strategies and unusual learning activities together with a high level of involvement and personal support for the pupils; the importance of *variety* in lessons as a means of stimulating interest in science was noted by Simpson and Oliver (1990), Piburn and Baker (1993), and, later, in the Scottish H.M.I. Report (H.M. Inspectors of Schools, 1994).

Lack of variety in tasks[18] can lead to poor attitudes towards a subject area. In all three of the International Science Studies (Comber and Keeves, 1973; Keys, 1987 and Keys et al., 1997) responses were collected about the frequency of note-taking (or copying from the board) in science lessons in order to assess their effects on pupil *performance*[19] but no attempts were made to evaluate the pupils' attitudes to these tasks in relation to their overall attitudes to science. More recently, Parkinson et al. (1998), noted that the girls' greater enthusiasm, compared with that of the boys, for the reading and writing aspects of science in the primary school continued after transition to the secondary school.

The need for teachers to adopt strategies to help learners develop their thinking has given constructivism (see Chapter 1) a key role in science teaching (Driver and Oldham, 1986). In 1993/4 primary teachers' understanding of science received adverse comment from OFSTED[20] inspectors. In their review the inspectors noted (OFSTED, 1995) that there were shortcomings in the teachers' understanding of science which were demonstrated by the incorrect use of scientific terms and an 'overemphasis on the acquisition of knowledge at the expense of conceptual development'. Problems linked with primary teachers' lack of confidence in teaching science were later noted by Harlen et al. (1995) and, in 1997, Harlen commented that children's reported difficulties with science were chiefly due to the insufficient explanations given to them by primary teachers.

[18] Bricheno (2001) noted that the boys' enthusiasm was sustained when a variety of learning approaches were used.

[19] In the Third (latest) International study, no associations were found between the frequency of copying notes from the board and mean science score (performance).

[20] Office for Standards in Education

Ponchaud (2001) has since suggested that recent government initiatives in numeracy and literacy may also act against attempts to deliver good primary teaching as science lessons have often been re-scheduled as short afternoon sessions and, for primary children particularly, this has proved more difficult to stimulate their interest and enthusiasm. Also, pupils' anxieties about performance in national tests (SATs) sometimes led to numerous revision sessions in preparation for the tests and these increased the pupils' boredom with science. This view was supported by Murphy and Beggs (2003) who, in a recent survey of over 1000, 8 to 11-year-old children in primary schools in Northern Ireland, criticised the tendency for science to be taught as a 'body of knowledge' in Years 5 and 6 and commented that this may have been driven by the emphasis on national tests[21] on content and knowledge.

Bricheno (2001) has also examined the extent to which teaching styles change on transfer from primary to secondary school. She observed an abrupt change between the primary teachers' skills-based, child-centred view of teaching and the secondary teachers' more subject-based, teacher-directed activities and commented that it seemed likely that the change in teaching style was linked with a change in the pupils' attitudes.

Pupils' perceptions of the quality of the teaching and the pupil-teacher relationship were regarded as important influences on pupils' attitudes to a particular subject by Hewison (1982) who noted that (in an Australian study with secondary age pupils) the 'serious' pupils enjoyed physics more when they had a 'serious' teacher but the 'playful' pupils in the same group enjoyed physics less with this type of teacher. Achievement-orientated teachers increased the enjoyment of competitive students (but had the reverse effect on non-competitive students). Haladyna et al. (1982) noted that the 'quality' of a science teacher, from the students' perspective, was defined by the teacher's enthusiasm for science and the respect which the student held for the teacher's subject knowledge[22]. Referring to the work of Pheasant (1961), Hewison cited the dislike of the teacher as the largest single reason for dislike of a subject.

Woolnough (1994c) identified the effective teaching of school science as having a significant influence on secondary pupils' attitudes to science and their decisions whether, or not, to continue with science education post-16. The two strongest influences on subject choices were the quality of their science teaching (based on the teacher's ability to relate to

[21] the Transfer Procedure Test (for entrance to selective grammar schools) at age 11.
[22] Subject knowledge was one of the most important attributes of a 'good' teacher (Wragg et al., 2000).

everyday contexts and to establish a good relationship with their pupils) and the students' positive experience of extra-curricular activities. Good teaching was identified by enthusiastic, well-qualified graduate staff with subject specialisms who could relate their subject to everyday contexts and who had good relationships with their pupils.

More recently, Miller et al. (1999), in a cross-sectional study of attitudes to all three core subjects, explored some of the many factors which contributed to teacher-pupil relationship. In all three core subjects, it was suggested that an approachable teacher was a main contributor to the pupils' learning.

3.2.1(ii) *Attitudes to science and practical work*

Ormerod and Duckworth (1975) reviewed much of the early literature on the influence of pupils' attitudes to practical work on their attitudes to science. Harlen et al. (1981) recognised the importance of practical activities (observation, measurement and the development of manual skills) in fostering positive attitudes to science and in promoting effective learning in the classroom. Noting that the girls were less keen than the boys on practical tasks, Hewison (1982) suggested that this might be due to the girls' lesser spatial abilities; she suggested that the science curriculum should be developed to incorporate more historical and philosophical issues which might be of more interest to the girls.

Cullingford (1987) noted that, although pupils reported that the practical work was what they enjoyed most in science, their enjoyment may well have been related to the greater variety of teaching styles and the more active approach involved in such sessions. Although much of the early research literature on attitudes to science has noted that the pupils' enjoyment of the subject was often linked to the amount of practical work[23] involved (see Appendices 3.1, 3.2 and 3.3), the value of some practical 'investigations' in the learning process has been questioned by Woolnough (1997) and more recently, by Reiss (2002, p.73).

[23] see also Keys et al. (1997).

3.2.1(iii) Achievement/performance in science

The relationship between pupils' attitudes towards, and their *achievement* in, science forms a substantial part of the research literature (Comber and Keeves, 1973[24]; Keys, 1987, Harris et al., 1997). Keys (1987) reported, for 14-year-olds, a moderate[25], positive association between the *perceived ability* in science and the pupils' *actual performance* in science (as shown by high test scores). The tentative proposals for this research study did not include any proposals further to evaluate this relationship but it was decided to include, in the secondary phase, some questions on the pupils' perceptions of their performance in order to investigate any links between this variable and the pupils' attitudes to science. The literature which links pupils' attitudes to achievement in science is, therefore, only cited where it is relevant to other issues.

3.2.1(iv) Attitudes and the perceived difficulty of science

Duckworth and Entwistle (1974) noted that a pupil's choice of subject at age 14 was negatively correlated with its perceived difficulty. Referring to Brown's (1972) monitoring of 12 to 14-year-old pupils in Scotland (to assess the outcome of changes to the science curriculum), Ormerod and Duckworth (1975, p.18) reported that, although the pupils found science easy and enjoyable, they felt that science courses for older pupils were "only for the brainy ones". Hewison (1982, p.192) also concluded that, for the majority of pupils, the perceived difficulty of a subject was negatively correlated with performance and science subjects were often regarded as the most difficult at school.

For the purposes of analysis, the perceived difficulty of the sciences of biology, chemistry and physics have usually been discussed separately. Ormerod and Duckworth (1975) recorded that Pheasant (1961) had observed that the physical science topics were regarded as particularly difficult by 15 to 16-year-old students *(n=1511)* in fifteen secondary schools (three direct grant schools and twelve grammar schools). Amongst the same age group, Duckworth and Entwistle (1974) found that even those who intended to study physics in the sixth form, regarded physics as the most difficult; biology was regarded as 'easy'. Research reported by Keys (1987)[26] suggested that, although the 10-year-olds found biology easier than physics, the 14-year-olds found chemistry the most difficult and physics the easiest. Referring to earlier research (Keys, 1978a and Duckworth and Entwistle, 1974), Keys commented (1987 p.143) that students generally perceived both physics and chemistry as difficult compared with other subjects.

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[24] a low, but positive, association between 'liking for school' and achievement in 10 and 14-year-olds

[25] there was a weaker association between these measures for the 10-year-old pupils.

[26] see Appendix 3.3.

Robinson (1969) acknowledged that biology and physics represented 'structurally different fields of knowledge'[27] and Shayler (1974) noted that chemistry and physics were generally regarded as more conceptually demanding than biology. Shayler's findings were later supported by the study of Driver et al. (1984) study in which students found the application of physics concepts more difficult than the application of chemistry or biology concepts. More recently, Havard (1996) in his study of 6th formers' attitudes to science confirmed that physics was seen as the most difficult of the three main sciences.

3.2.1(v) <u>*Pupil ability*</u>

The level of enthusiasm demonstrated by pupils for the sciences has been linked with pupil *ability*. Ormerod and Duckworth (1975) cited Hudson (1963) who showed that in a study of boys with high intelligence scores, the three most favoured subject preferences were the physical sciences, classics and modern languages. Many of the measures investigated in the G.I.S.T. study (Kelly, 1986, see Appendix 3.1) were related to either the pupils' I.Q. scores on entry to the secondary school or to the pupils' *performance* during the period of the study – see also 3.3.1(iii). It was not the intention of the proposed research study to link pupils' attitudes to science with any measure(s) of their ability and so the literature is only cited when it is relevant to other issues.

3.3 Gender and subject preferences

The Swann Report (1985) had noted that, at age 11, boys and girls seemed to be equally interested in science but the specific themes of their interest were often different. Ormerod and Duckworth (1975) had referred in their review to the work of Koelsche and Newberry (1971) who noted the preferences of 10 to 12-year-old boys for a wide range of physical science topics (including 'earth and space'). Ormerod and Duckworth also referred to the research carried out by Bradley and Hutchings (1973) who recorded the boys' preferences for the physical sciences (often associated with the destructive elements of warfare etc.) and the preferences of the girls for the biological sciences (regarded as more relevant to the caring professions). Kelly (1986) commented on the boys' greater interest, compared with the girls, in 'spectacular'[28] science and, more recently, Murphy and Beggs (2003) in Northern Ireland, observed that the boys' preferred 'forces and friction' and 'electricity' whereas the girls' preferences were for 'healthy living', 'plants', 'materials' and 'ourselves'.

[27] quoted by Ormerod and Duckworth (1975, p.14).

[28] animals in the jungle, volcanoes, earthquakes, acids and chemicals (Whyte et al. 1985, p.80)

Ormerod and Duckworth (1975) concluded that physics and chemistry were often regarded as 'male' subjects[29] and that there were factors within schools which might deter girls from studying them. Nearly forty years ago, Ballham (1964) had noted that the psychological profiles of boys studying G.C.E. biology were closer to those of boys studying arts subjects than to those of boys studying the physical sciences or mathematics. Ormerod (1975b) suggested that the boys regarded biology as 'female' (much as the girls' regarded physics as 'male') and this reverse polarisation[30] of the boys may explain, at least in part, the boys' reduced interest in biology. Whyte et al. (1985, p.82) commented:

> "Girls are not uninterested in science, they are bored by the limited version of it they meet in school."

Whyte et al. (1985, p.81) also referred to observations in the G.I.S.T. study (Kelly, 1986) - see 3.1.3(i) - where "boys acted in a way which made science seem more masculine than it is" and the teachers helped to create the impression that science was "a very macho business". In a study of subject preferences of 11 to 13-year-olds, Colley, Comber and Hargreaves (1994) identified significant gender differences in subject preferences among 11 to 13-year-old pupils and noted the boys' preferences for P.E. and science and the girls' preferences for English and the humanities.

Gender may not, however, be the major determinant of preference for the physical, or biological, sciences - according to Ormerod (1975a), students who planned to continue with a study of the physical sciences, already needed to hold favourable views about the social implications of science (i.e. a pre-existing positive attitude to science needed to be present). In contrast, students who pursued biology tended to have more 'intrinsic trust' (Ormerod and Duckworth, 1975, p.14) in the beneficial effects of the biological sciences and did not necessarily already hold such positive views.

Some possible reasons for the girls' negative attitudes[31] were put forward by Stanworth (1981) who commented that the girls' exposure to gender discrimination in the 'hidden curriculum' began well before their transition to secondary school (see also Clarricoates, 1978 and Skelton, 1989). She also commented that the range of "out-of-school"

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[29] Pell and Jarvis (2001) have suggested that the absence of any gender difference in attitudes to science experiments at primary school does not support Kelly's view that, at primary level, science is regarded as a 'male' subject.

[30] 'each sex in the presence of the other asserting its masculinity or femininity by greater preference and choice of subjects of the same gender and less preference and choice of subjects of the opposite gender' Ormerod and Duckworth (1975, p.68).

[31] Tobin (1997) has suggested that the girls' lack of enthusiasm for science might be related, not only to boys' greater demands on teacher time, but on their monopolisation of the available science equipment.

experiences and, especially, the role-models provided by family and friends may be significant factors in influencing girls' expectations. Smail (1984a) referred to work (Harvey and Edwards, 1980 and Smail and Kelly, 1984b) which demonstrated that, by 11 years of age, potential female scientists could already be identified and, by this age, gender differences in interest in the biological and physical sciences were already evident. She also observed that a masculine self-image most clearly identified potential physical scientists; girls saw themselves as less feminine, less attractive socially and less like their mothers than the girls who were studying biological science.

Hewison (1982), referring to Pheasant (1961), noted that even before they were exposed to much school science girls, more than boys, identified science and technology with insensitivity and indifference and attributed this, at least in part, to teachers' failure to demonstrate the positive contribution of science to human welfare. This lack of promotion of the beneficial aspects of science was also commented on in the APU study (Department of Education and Science, 1986 – see 3.1.3 (ii)).

Keys (1987), Measor and Sikes (1992) and, more recently, Miller[32] et al. (1999) have commented on the less favourable attitudes to science adopted by girls, compared with those of the boys[33]. Keys (1987, p.141) suggested that the lesser experiences of young girls in handling 'scientific' toys may nurture gender stereotypes (see also Maccoby and Jacklin, 1974[34] and Kelly, 1978). Despite their greater enthusiasm than the boys for general reading, secondary-aged girls' lesser enthusiasm for reading science-orientated books (where illustrations often depicted boys in the key roles i.e. holding the Bunsen burner) might also be an important factor in their lack of interest in this type of reading material.

Johnson and Murphy (Department of Education and Science, 1986) in their research carried out for the A.P.U., noted that the boys tended to engage in 'tinkering' activities such as dismantling mechanical objects, playing with electrical toys or building models and they were more likely than the girls (who preferred 'home-making' activities e.g. cooking and sewing) to read science-fiction stories. Tutchell (1990), added another dimension by suggesting that primary children's perceptions of gender roles might be reinforced by the stereotypes presented in many of the traditional fairy tales and nursery

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[32] The girls demonstrated negative measures for science in Year 10 and there were significant gender differences, in favour of the boys, in both Years 9 and 10.

[33] Bricheno (2001) in her recent study of pupils in Essex schools, suggested that, between the ages of 10 and 12, the boys' attitudes to science declined more rapidly than those of the girls.

[34] There was some suggestion that the children, not the parents, controlled the choice of toys.

rhymes. Concerning the best time for intervention, Short and Carrington (1989) in their study of perceptions of children aged between 6 and 11, suggested (p.37) that the fourth year of the primary school (Year 4) "may be the best time to begin plugging the gaps in children's knowledge of the origins of stereotypes".

3.4 "Out-of-school" factors

3.4.1 Parental and home factors

Factors outside the immediate school environment may influence pupils' attitudes to science and other subject areas. Ormerod and Duckworth (1975) commented on Pheasant's (1961) survey of 1,511, 16-year-olds which demonstrated that, except at the lowest socio-economic level of parents, the influence of home was greater than that of school in determining in the pupils' *uptake* of science. There was, however, a rather confused picture of parental influence as the pupils were unwilling to admit parental pressures in relation to subject choice within school and the parents' views were not sought directly.

Ormerod and Duckworth's review also referred (1975, p.99) to several studies (Chown, 1958; Meyer and Penfold, 1961 and Hill, 1965) which suggested that when the variables of home and school were compared, the strongest effect on the pupils' interest in science was the home and, within the home, the attitudes of the parents towards science seemed to be an important factor. Butler (1966) suggested that, although the influence of the school may be a major factor in determining such 'external' criteria as subject, or career, choices, home influences were more important on 'internal' criteria such as interest in science.

Ormerod and Duckworth's review (1975) also included many other references to the parental influences on pupils' attitudes; they noted that the greater influence on London pupils' interest in science was that of the father[35, 36] (Meyer, 1961). Although a positive relationship between the father's occupational status and the pupils' enjoyment of science was noted by Gardner (1975), other literature cited by Ormerod and Duckworth (1975) suggested that the father's *interests* (as perceived by the child), rather than the father's *occupation* were more important influences on the child's interests. (The influence of relatives in scientifically-orientated employment on the child's interest in science was also documented.)

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[35] In Sydney, the mother exerted the greater influence (Meyer, 1963).

[36] Regarding parents', particularly mothers', involvement with their children's interests, Donaldson (1978) and, later, Walkerdine and Lucey (1989), commented on the relationship between parental involvement and social class.

Not all research has quantified the relationships between "out-of-school" factors and pupils' attitudes to science. Ormerod and Duckworth (1975) also referred to the findings of Kelly (1961), who noted that the "out-of-school" influences on pupils' subject choices were few and varied in their effects, and Hutchings (1975) who observed that uptake of science subjects appeared *not* to be conditioned by parents or outside influences.

Although attitudes are positively associated with achievement (Keys, 1987, p.159), much of the research on "out-of-school" factors (Keeves, 1975; Weidling, 1985 and Keys, 1987) has focussed on the effects of the home environment or the socio-economic level (according to various criteria) of the parents on the pupils' *achievement*[37] in science rather than on subject choices or attitudes towards different subject areas. However, one study which did take account of pupils' attitudes was that of Breakwell and Beardsell (1992) who noted that children from higher social classes demonstrated *less* positive attitudes to science.

In the Second International Study (Keys, 1987), the home background composite measure accounted for 20% of the *achievement* in science of 10 to 14-year-old students and the home and student factors taken together accounted for about 50% of the variation in science achievement. The home background factors, were, however, far less important in determining science achievement among able students who chose to continue with science beyond the compulsory age. Keys (1987, p.155) noted that, in agreement with many of the earlier studies, the relationship between school and teaching factors and achievement was not very strong when allowance was made for the home and student factors.

Pupils' *attitudes* to science were, however, considered by Keeves (1975) who attempted to quantify the effect of some of the "out-of-school" factors (such as the educational environment of the home) on pupils' achievement in science and mathematics over the first year in their secondary school. Keeves felt, however, that the pupils in the elementary (primary) school might not have been taught science in a 'systematic way' and that their attitudes to science at this point might be regarded as 'unstable and unreal' (Keeves, 1975, p.448). For this reason, the pupils' attitudes towards their secondary school (on entry) and school learning at the end of the elementary school were regarded as the best indicator of their attitudes towards a 'new' subject in the curriculum. (Pupils' attitudes towards *science* were only assessed after one year in the secondary school at which point attitudes to

[37] A strong link between pupil *achievement* and parental attitudes was also demonstrated in the study of more than 3000 children undertaken for the Plowden Committee (Peaker,1967).

science and a measure of interest in science were found to be stronger influences on *achievement* than attitudes towards school and school learning).

Although Keeves' research focussed on achievement in, rather than on attitudes towards, science, some of the observations have relevance to this research study. It was assumed that initial achievement did not directly affect pupils' attitudes but a non-causal link was suggested between the initial achievement of the student in science (and mathematics) and the structural characteristics of the home e.g. the parents' occupations, level of father's education, religious affiliation, number of children in the family and the mother's occupation before marriage. The factors which influenced final achievement in science were the pupils' initial achievement in the subject, the attitudes and practices in the home[38] and, to a lesser extent, the 'structural characteristics' of the classroom (e.g. whether the teacher was a science specialist, the number of lectures attended by the teacher during the year (1969), the number of students in the class and the teacher-pupil relationship. In this study of complex inter-relationships (see Appendix 3.4), it was assumed that prior conditions e.g. the pupils' achievement, attitudes and gender influenced the attitudes and practices[39] within the home (but not the structural characteristics of the home). The gender of the *pupil* was also regarded as having an influence on *parental* attitudes with the boys' having greater influence on their parents' attitudes than the girls.

Keeves (1975) also commented that while 46% of the total variance in achievement appeared to be explained by the antecedent variables (see Appendix 3.4) these variables shared about two-thirds of their effects with the home, classroom and peer group factors. About 47% of the variance associated with the criterion measures remained unexplained and Keeves suggested that this proportion was associated with the attitudinal measures which were of 'lower reliability and validity than the achievement measures' (Keeves, 1975, p.457).

Keeves acknowledged that, although achievement and attitudes were interrelated, there were strong components of the attitude measures which seemed to be largely independent of achievement. He concluded that if low parental attitudes could be raised by stimulating a greater involvement in their child's schooling, then the pupil's achievement level in science was also likely to be raised (see also Solomon, 1994).

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[38] The influence of home practices on the pupils' learning was less pronounced for mathematics and the author suggests that the influences of the home may well very according to the nature of the subject.

[39] e.g. parents' attitudes towards the child's present occupation, parents' ambitions for the child's future education and occupation and parents' hopes and aspirations for themselves.

3.4.2 Hobbies, interests and activities

The APU study (Department of Education and Science, 1986) noted that the differences between the boys' and the girls' early scientific experiences and interests continued through to their teenage hobbies and activities. Compared with the girls, the boys engaged in more 'tinkering'[40] activities and it was suggested that this might explain the boys' greater confidence in formal practical work in the secondary school. Keys (1987, p.151) also noted that the issues on which the boys out-performed the girls by the greatest amount were those related to "out-of-school" interests generally favoured by the boys.

The contribution of "out-of-school" factors (e.g. home background, extra-curricular activities including scientifically-orientated preferred learning activities[41] both inside and outside school) as well as the students' personality traits[42] to pupils' achievement in science or subject choices was noted by Woolnough (1994b) in his study of over 1000, 18-year-old students about to embark on science or engineering courses in higher education. There was a general trend for the students' attitudes to science as well as their technical hobbies and skills to have been influenced by a scientific home background, for example, parental study at higher education level of one or more of the sciences. Although outside the age range of the proposed research study, the importance of extra-curricular activities in influencing pupils' subject choices was emphasised.

The home as a 'receptor' of school science was one of the main points of interest in Solomon's (1994) study. The study was designed to encourage involvement between parents and children, with help from teachers, in home-based science activities and to construct a tentative model of the effects of the home on education. The qualitative data (collected by semi-structured, tape-recorded interviews) illustrated the different approaches which parents adopted with their children and, although the focus of the study was not on parental attitudes to science as such, Solomon noted (p.569) that "the parents' attitudes to science[43] overlapped with those they held on education".

Woolnough's more recent, smaller study (Woolnough, 1996) of pupils *(n=654)* in Years 7 to 11 in Oxfordshire attempted to investigate the influence of extra-curricular activities (lectures, hobbies, T.V. programmes) on attracting pupils to take up a scientific career. He reported (Woolnough, 1996, p.305) that, disappointingly, many pupils left this section of

[40] e.g. dismantling mechanical objects, assisting with car maintenance, playing with constructional and electrical toys (Department of Education and Science, 1986, p.19)
[41] science clubs, competitions, speakers from, and visits to, local industry
[42] identified as 'extrovert', 'thingperson', 'slogger' or 'sharpone' (Woolnough, 1994b, p. 672)
[43] See also Geake's (1993) comments on parents as a valuable resource in primary science education.

the questionnaire unanswered 'probably thinking that there was nothing which attracted them to a job in science'. The pupils' hobbies (e.g. car maintenance, car racing, sports, work with animals etc.) were, however, suggested as being positive influences on their choices. Parents and other close relatives who had science-related jobs were cited as influencing factors but, according to Woolnough (1996, p.305) not necessarily positive ones.

3.5 The scope of the published research

In the 1960s and 1970s, the influence of Equal Opportunities legislation on the education system encouraged researchers to examine the apparent "switch-off" from science being demonstrated particularly by the girls. The studies which followed therefore concentrated on gender issues and attempted to make science more "girl-friendly" with the aim of encouraging the uptake of science, particularly the physical sciences, at age 14 (i.e. the option choices stage).

The studies of "in-school" factors which may affect pupils' attitudes to science have concentrated on secondary pupils' interest in, and enjoyment of, school science (including practical work) and the strategies adopted within the school for teaching and learning. Consideration has also been given to issues such as the perceived difficulty of science and its effect on the pupils' attitudes. Many of the studies in the secondary phase have focussed on the relationship between performance, or achievement, and attitudes to science. There has been considerably less research in the primary phase or on pupils' attitudes on transfer between primary and secondary schools.

The possible relationship between environmental or home/parental factors (such as the parental experiences of, and attitudes towards, the subject area) and the pupils' *attitudes* to various aspects of science have received little attention. The findings from the literature review made it possible to define more closely the research design and methodology of the proposed study - this is discussed in Chapter 4.

Chapter Three: Review of the literature on pupils' attitudes to science

3.6 Summary

Much of the pre-National Curriculum research has focussed on pupils' apparent lack of interest in school science, particularly the physical sciences, and most of the research studies have, therefore, attempted to assess separately (with respect to gender) attitudes to the biological and physical sciences. Compared with the secondary phase[44], much less research has been published which is relevant to the primary phase and, by the mid 1990s, little relevant research had been carried out on pupils' attitudes over primary-secondary transfer at age 11. Three major research studies of the 1980s were outlined at (3.2). Apart from the G.I.S.T. study (Kelly, 1986), conducted in the secondary phase, relatively little of the research literature on pupils' attitudes to science was based on longitudinal studies.

The importance of relevant practical work in the establishment of positive attitudes to science was emphasised in most of the literature and many references related to the link between attitudes to science and *pupil ability*. There were suggestions that the *perceived difficulty* of science may be linked with negative attitudes and there have been suggestions that only the more able pupils may choose to continue with science, particularly physics, beyond age 16. In the secondary sector attitudinal studies have mostly concentrated on the relationship between attitudes and *examination performance* or *achievement* in the sciences rather than on some of the underlying, or associated, factors which might influence the formation and stability of pupils' attitudes. Studies, particularly during the last decade have shown the importance of the quality of the science teaching and the pupil-teacher relationship in establishing positive attitudes to science.

There has been relatively little recent research on pupils' attitudes to science compared with other subjects (e.g. the humanities), particularly in the primary phase. Pupils' *attitudes* towards various aspects of school science and the pupils' "out-of-school" activities or home/parental factors have not received much attention. Where research literature was available (e.g. Keys, 1987), this usually focussed on attempts to link the out-of-school" factors with the pupils' *achievement* in science, rather than with their *attitudes* towards the subject.

[44] After this research study was initiated Weinburgh (1995) produced a meta-analysis of the literature from 1970 to 1991.

Chapter Four: Methodology for the study

Introduction

The literature review (Chapter 3) had identified the nature, breadth and duration of studies on pupils' attitudes to science prior to the inception of the National Curriculum. On the basis of the outcome of these studies, the longitudinal study would now attempt to establish the answers to the following research questions:

1. Did pupils who were exposed to the new compulsory curriculum (Chapter 2) demonstrate more positive attitudes to various aspects of school science than those reported in the pre-National Curriculum literature (Chapter 3) for pupils in the same age group?
2. Compared with pre-National Curriculum findings, was there any improvement in attitudes, particularly those of the girls', to the physical sciences in the early secondary years?
3. If attitudes were not being improved, at what age were pupils losing interest in science and what might be some of the underlying "in-school" reasons for this?
4. How did pupils' attitudes to school science compare with those towards other school subjects?
5. Were there any relationships between the nature of the pupils' "out-of-school" hobbies, activities and interests and the pupils' attitudes to various aspects of school science?
6. Were there any relationships between parental attitudes towards, and experiences of, science (including parental involvement in home-based activities such as 'tinkering') and the pupils' attitudes to school science?

and

7. Using multiple regression techniques, applied to both the "in-school" and "out-of-school" data, could any predictors of the pupils' attitudes to science at various stages of the study be ascertained?

In order to answer these questions and to compare the data with those from the pre-National Curriculum literature, it was clear that the study would also need to:

- *take separate account of attitudes towards the physical and biological sciences;*
- *be of at least three years' duration;*
- *span both the primary and secondary phases and*
- *take due account of gender considerations.*

4.1 Research design

Kelly (1986) commented that most studies up to the mid-1980s had been cross-sectional (rather than longitudinal) so they were unable to assess the stability of children's attitudes and age-related developments for the same pupils could not be identified. In view of Kelly's comments, and supported by a further literature search, it seemed likely that any study of the changes in pupils' attitudes would probably be most appropriately examined through a longitudinal study.

A longitudinal study, rather than one of cross-sectional design, is appropriate if changes in pupils' attitudes to science over a period of time are to be monitored:

> "For some purposes, longitudinal research is the only acceptable option. If the purpose is to measure historical or developmental change, a longitudinal design is essential, especially to separate age, period and cohort effects."
>
> (Menard, 1991, p.43)

Menard (1991, p.4), used the term 'longitudinal' to describe a group of research methods in which the data for each item or variable were collected at least twice over a period of time, the subjects of the study were the same (or at least comparable) between the points of data collection and the data analysis involved some comparison of data acquired from the two (or more) points of data collection.

Whilst pointing out some of the limitations of longitudinal studies, e.g. the effects of repeated contact between the researcher and the respondents which might change the respondents' willingness to answer questions, Menard (1991, p.38) cited the primary objectives of longitudinal research as: i) to describe patterns of change, and ii) to describe the direction and magnitude of causal relationships.

> "There is nothing unique about the methods used to collect data for longitudinal research. Longitudinal research, like cross-sectional research, relies upon three fundamental methods of gathering data: asking people questions, observing people's behavior, and observing the physical traces or results of people's behavior."
>
> (Menard, 1991, p.31)

The advantages and disadvantages of the various approaches[1] to the collection of attitudinal[2] information were discussed in some detail by Henerson et al. (1987). An examination of the literature on attitudinal research, particularly that carried out in the 1980s (see Chapter 3), suggested that the most common method of data collection was by written questionnaires (sometimes presented in booklet form).

Particularly in a school situation where the time available for data collection is severely restricted, large numbers of pupils can provide data with minimum disruption to timetables and the possible influence of the researcher on the pupils' responses is minimised. The disadvantages may include the inadequate validation of the measurement scales (Gardner, 1975) and possible problems with literacy (allowance for this may need to be built into the schedule). In the proposed research study, pupils would only experience one exposure to each of the questionnaires – clarity and simplicity would be of major importance – and the timing and location of such information gathering would be mostly outside the researcher's control.

Questionnaires are useful instruments for the collection of both quantitative and qualitative data. May (1993) discussed both quantitative and qualitative methodologies and suggested that they were not mutually exclusive:

> "Differences between the two approaches are located in the overall form, focus and emphasis of the study."
>
> (May, 1993, p.114)

Robson (1993) warned of the criticisms which might be made of research based entirely on qualitative data:

> "Anyone moving way from studies based on quantitative data is likely to have to face criticisms that the work is unreliable, invalid and generally unworthy of admission into the magic circle of science".
>
> (Robson, 1993, p.402)

The collection and analysis of quantitative data permits fairly quick access to information on trends and patterns but because of its reductionist nature it cannot reveal any reasons for cause and effect. Qualitative data allow causal explanations to be attempted but, because

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[1] interviews, surveys and polls; questionnaires and attitude rating scales; logs, journals, diaries, reports and observation procedures.

[2] Henerson et al. (1987, p.13) regarded 'attitudes' in a broad sense i.e. describing "all the objectives we want to measure that have to do with affect, feeling, values and beliefs."

smaller sample sizes are often involved, bias may occur if the researcher is not detached from the situation (as in the conduct of tape-recorded interviews). Cohen and Mannion (1994) advised of the need for triangulation by combining several methods in order to improve validity and reliability thus overcoming the disadvantages of using only one method (see also Robson, 1993).

Cohen and Mannion (1994) also discussed the relationship between the researcher's conceptions of the social world and the researcher's choice of methodology. In the proposed longitudinal study, a broadly positivistic approach would be taken with qualitative data being used to support the quantitative analyses.

In order to compare the data from the proposed research study (particularly where annual trends were likely to be involved) with those provided by the pre-National Curriculum literature (Chapter 3), it was important to collect quantitative, supported by qualitative, data on the specific issues included within each of the questionnaires. The qualitative comments would be elicited (using 'open' questions on the questionnaires) in order to provide some 'rich data' (see Robson, 1993, p.370) which would hopefully give some more detailed insights into the reasons underlying the pupils' attitudes. At the end of the study, the outcome of the data analyses would need to be considered against a background of numerous changes in social and economic conditions, as well as within schools themselves, between the time of the pre-National Curriculum research studies and the completion of the proposed research.

4.2 The measurement of attitudes

The nature of attitudes and their formation was outlined in Chapter 1. The complex problem of attitude measurement and analysis was discussed by Oppenheim (1966) who emphasized that the problem was unlikely to be solved by the application of a single design, or 'best method':

> "The function of research design is to help us obtain clear answers to meaningful problems."
>
> (Oppenheim, 1966, p.7).

4.2.1 Attitude scales

The more common techniques for attitude measurement try to locate people on a unidimensional scale of favourability (i.e. to what extent the attitude object is liked or disliked). A literature review revealed that 5-point[3] Likert scales (Likert, 1932), or scales based on this principle, were generally the most popular in questionnaire-based studies (Oppenheim, 1966; Henerson et al., 1987 and Eagly and Chaiken, 1993).

As brevity and simplicity of language were going to be two of the most important factors influencing the choice of the attitude measurement techniques to be used in this longitudinal study, the Likert model was thought to be appropriate and was, therefore, used as the basis for most of the questions relating to particular topics and investigations and/or practical work. The use of the Likert scale does, however, sacrifice some accuracy for simplicity. The interval differences between the scaled responses, e.g. "disliked a lot" (=1) to "liked a lot" (=5) are not strictly equal (the 'distances' between values are arbitrary). The scores are treated as ordinal for the purposes of calculation but some degree of distortion may be present. Gross (1992) warned that responses to written questionnaires using this type of model may tend to cluster around the middle of the scale.

Likert's aim was to devise a simpler, less time-consuming scaling method than that produced by Thurstone[4] (Thurstone and Chave, 1929, cited in Oppenheim, 1966). Although it is possible to derive scales which have a similar theoretical basis to Thurstone's scale, but which do not use 'equal interval' models, the time and effort required to derive such attitude scales have made these techniques generally less attractive despite the use of computerised data handling techniques (see Eagly and Chaiken, 1993). Other scales e.g. ratio scales, where the numbers used must reflect distances from a unique origin or zero point (Himmelfarb, 1993, p.23) were rejected as inappropriate for this investigation. Other methods of attitude measurement such as Osgood's Semantic Differential[5] (Osgood, Suci and Tannenbaum, 1957, cited in Oppenheim,1966) and Guttman scaling techniques (see Eagly and Chaiken, 1993) were also rejected as either too complicated or inappropriate for the age range of the respondents particularly when only a single contact with the respondents would be possible.

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[3] Score to statements are usually: 5=strongly agree, 4=agree, 3=undecided/do not know (sometimes omitted), 2=agree and 1=strongly agree.

[4] This model attempted to derive an 'equal interval' scale by placing each stimulus into one of a number (usually 11) of rating intervals according to how favourable, or unfavourable, an evaluation it expressed. A wide range of statements (covering the attitude object) were collected and judged by a panel according to their positive, or negative, attitude on an 11-point scale.

[5] based on ratings of the attitude object on adjective scales which attempt to represent generalised 'evaluative beliefs' (e.g. that a particular attitude object is 'good' or 'bad') for at least nine pairs of bipolar adjectives. '

Some published attitude to science scales which measured a variety of constructs, for example Fraser's (1978) Test of Science Related Activities (T.O.S.R.A.) and those designed for the use of 10 to 14-year-olds in the Second International Mathematics and Science Study (Keys, 1987), were examined to see whether they could form the basis of some of the specific questions posed by the research study.

An earlier attitude scale, the Brunel Attitude Scale (Ormerod, 1976) focussed on attitudes to school science but it was developed for 14 to 16-year-olds in selective schools and most of the questions were not, therefore, appropriate for the younger age group[6] of pupils participating in the proposed study.

It was not intended that the proposed research study should develop a psychometric test but that it should aim to assess the pupils' responses to research questions pertinent at the time. On this basis, and subject to any amendments after piloting, it was decided that the use of concisely-worded single questions (rather than multiple questions/statements aimed at the same construct) would be used which were specific to each of issues under investigation.

4.2.2 Additional qualitative data

Hewison (1982) in her research study had made an attempt (which she later abandoned) to introduce "mini-essays" in order to gather more data and it was decided that, at the end of the primary phase of the longitudinal study, the pupils would be asked to contribute a "mini-essay" and/or drawings about their good, or bad, feelings about school science as these might provide additional[7] qualitative information which might not have been elicited by the more structured questionnaires.

Comments in the literature (Chapter 3), particularly those of Glenny (1995, p.6), on the benefits of talking with children about their school experiences and how they build up their constructs and 'make sense of their world' suggested that the inclusion of some brief, semi-structured, tape-recorded interviews with a small sample of the cohort might also be an appropriate means of collecting useful qualitative information on the issues underlying

[6] More recently Pell and Jarvis (2001), in an attempt to explain how pupils' attitudes to science were affected by primary teachers' competence in the subject, developed three attitudes to science and attitudes to school scales for use with children between 5 and 11 years of age.

[7] James (1995) suggested that children should be encouraged to use different methods of communication (drawings, stories, etc.) in their responses to questions.

pupils' attitudes. Triangulation (Greig and Taylor, 1999, p.75) of the questionnaire responses with the transcripts of tape-recorded interviews, where available, would be undertaken and parental information on "out-of-school" activities could be checked against the information provided by the pupils.

4.3 Reliability and validity

Reliability was defined by Eagly and Chaiken (1993) as the extent to which, using correlation coefficients, any measuring instrument would give consistent scores or values over repeated observations. Where repeated observations were not carried out the term could be interpreted as the 'internal consistency' of a set of items used for measuring a particular construct.

In the proposed study, there would only be a single opportunity each year to administer the questionnaires (designed to assess pupils' responses to specific issues related to science) and so a check on the reliability of repeated observations was not appropriate. The longitudinal nature of the study meant that from year to year a change in the number and range of items (e.g. the specific topics studied in the biological and physical sciences) was to be expected. However, the 'internal consistency' within, for example, the topics/modules making up the physical sciences and biological sciences categories was examined using Cronbach's alpha (Aron and Aron, 1999, p.527) and, where appropriate, any particularly low scoring item (for example, the 'materials' topic in the physical sciences in Years 5 and 6) removed to improve the reliability.

Where requests were made to state the level of agreement/disagreement with, for example, the statement 'Science is interesting' (Year 8) correlations were undertaken with opposing statements ('Science is boring') to check for the consistency of responses.

As well as reliability, a measuring instrument should have 'external' and 'internal' validity[8]. The larger the sample the greater the 'external' validity (although, unless randomised, sampling bias can be a problem) and the greater the validity the more the generalisability of the data. Lack of clarity in the wording of the instrument can affect the ability of the instrument to measure what it is intended to measure i.e. its 'internal' validity is lowered. Particularly in the primary years, the need to include relatively few clear, but brief, questions would be a priority, attempts were not being made in this longitudinal

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[8] Robson (1993) defined validity as the extent to which the instrument measures what it claims to measure.

study to set out an attitude scale which would have psychometric[9] properties (and where the related items should, after factor analysis, give sets of unidimensional items which represent single constructs[10]). Correlations would, however, be conducted (where appropriate) when supplementary questions were presented on associated issues.

4.4. Other errors

Oppenheim (1966, p.7) cited design and sampling errors, respondent unreliability, interviewer and recording bias, processing errors (including errors in statistical analysis and/or faulty interpretation of results) as some of the common sources of error in attempting to find 'clear answers' to research questions. Robson (1993, p.374) listed twelve of the 'deficiencies and biases' of human observers (referred to as 'natural analysts') which might affect the interpretation of qualitative data. These included the observer's possible resistance to change 'first impressions' data in the light of later evidence, a tendency to discount the 'novel or unusual', or excessive confidence in the observer's judgement. Referring to qualitative data, Robson (1993, p.403) pointed out that the conventional concepts of internal and external validity, reliability and objectivity tend to be inappropriate when dealing with qualitative data and four alternatives (credibility, transferability, dependability and confirmability) were proposed.

The proposed longitudinal study was to involve purposive sampling - the sample size would be controlled by the number of primary schools in the selected location eventually agreeing, together with a single comprehensive school, to participate in the study and the time available to the researcher to conduct the proposed interviews.

In the proposed study there would be no opportunity to repeat the data collection and Henerson et al. (1987, p.20) warned of the rather low level of reliability of paper-and–pencil, self-report measures for young children. They commented that "the responses of young children are highly dependent on the events of the moment" and that problems associated with vocabulary and interpretation might lead to significant distortion in the final analyses. They acknowledged, however, that it was fair to assume that children had "no reason to lie about their attitudes" (Henerson et al., 1987, p.20). Summers (1970) commented, however, that there may be compelling reasons, conscious and unconscious, why respondents may not give 'completely accurate' self-reports.

[9] Henerson et al. (1987) recommended that in psychometric tests three or four questions should ideally be aimed at essentially the same attitude and 'internal consistency' measured using Cronbach's alpha.

[10] 'construct validity'

Systematic errors e.g. the tendency to give socially desirable[11] responses, could contribute to the measuring instrument's invalidity; children might well be inclined to give over-generous ratings in the expectation of appearing polite and compliant and pleasing the interviewer. The pupils' participating in the proposed study would be given assurances of confidentiality and all responses would be coded (see 4.5).

Mayall (1994, p.11) noted that discussions about data collection involving children tended to focus on the perceived problems such as children making things up to please the interviewer or children not having enough experience or knowledge to comment on their experience. The children's responses were often socially constructed and tended to repeat what they have been told by adults. She commented, however, that these observations could also apply to adults and that it was the knowledge needed to analyse and interpret data at the right level which was important. More recently, Morrow and Richards (1996), in their discussion on the ethics of social research with children, noted:

> "........provided one treats one's research subjects with respect and is aware of the limitations of one's methods, then collecting data from children is an obvious way to gain insight into children's lives and experiences."
>
> (Morrow and Richards, 1996, p. 95)

Morrow and Richards (1996, p.95), quoting Thomson (1992, p.60) suggested that "children from a surprisingly early age can understand basic elements of the research process and their role within this if the information is presented in an age-appropriate manner."

The advantages of including tape-recorded interviews within longitudinal studies (particularly if there were non-readers in the group) were discussed by Henerson et al. (1987) and many of the practical considerations[12] which later informed the interviewing procedures used in this research study were based on the recommendations of these researchers. Henerson et al. (1987) regarded an interview simply as a 'face to face' meeting between two or more people in which the respondent answered questions posed by the interviewer.

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[11] an answer which the pupil thinks the researcher / teacher will expect

[12] e.g. informing the interviewee, at the beginning of the interview, of the likely length, and scope, of the questions on the schedule.

Morrow and Richards (1996), citing research on children as witnesses, suggested that children could give reliable testimonies provided they were not asked leading questions.

> "Sociologists can and should take children seriously as social actors in their own right, as sources of valid sociological data".
>
> (Mayall, 1994, p.98)

4.5 Ethical issues

Regarding the ethical issues associated with interviewing children, Mayall (1994, p.102) pointed out that "discussions about ethical and social research in general focus on qualitative methods as having the potential for most intrusion."

Morrow and Richards (1996) noted that, although researchers usually seek the consent of adult 'gatekeepers' when wanting to interview children, there was a distinction between 'consent'[13] and 'assent'[14] as far as children were involved. More recently, Greig and Taylor (1999) have discussed the ethical implications of educational research in some detail.

At the point of initiation of this study, the Headteachers' approval was sought in all instances of proposed contact with the children. On every occasion when the questionnaires were administered a brief explanation was given to the pupils about the purpose of the study, confidentiality was assured and an opportunity not to be involved was offered (an alternative exercise was available). No pupils asked to be excluded from the survey.

The parents were notified individually by letters (sent via the school) which outlined the objectives of the research and requested their co-operation in the completion of (coded) questionnaires. These questionnaires, about the parents' attitudes towards, and experiences of, science would be matched with the questionnaires which their son/daughter would be asked to complete within the school environment. In addition to the school telephone number, a personal number was provided for any queries which might arise from the proposal (none did). The return of the questionnaire was assumed to signify their understanding of the objectives of the exercise and an implied agreement to participate

[13] 'informed consent': a process whereby an adult 'voluntarily agrees to participate in a research project, based on a full disclosure of pertinent information' (Tymchuk, 1992, p.128, cited by Morrow and Richards, 1996, p.94).

[14] 'permission and assent': a parallel process in which the parent or guardian agrees to allow a minor ward to participate in a research project and the child assents or agrees to be a subject in the research (Tymchuk, 1992, p.128 cited by Morrow and Richards, 1996, p.94).

together with their son/daughter in the proposed study. Only the data from families where positive parental involvement had taken place were included in the analyses (hence the lower than expected sample size). Primary pupils whose parents had not returned completed questionnaires were designated as 'non-cohort' pupils and, in certain instances, their quantitative data were used to provide some cross-sectional data (see Chapter 5). In the secondary phase, non-cohort pupils were invited to submit their questionnaires anonymously (but virtually all of these pupils added their names).

Some time after the completion of the fieldwork (March 2000) the Oxford Brookes University Code of Practice (Ethical Standards for Research involving Human Participants) was finalised. The procedures adopted during the fieldwork for the research study were in general agreement with those made in the document.

4.6 A framework for the study: "in-school" and "out-of-school" factors

Having identified (see Chapter 3) some of the "in-school" factors to be covered in the proposed research, Keeves' 'Paradigm for the Study of Educational Environments' (1975, p.440), which demonstrated the complex inter-relationship (Appendix 3.4) of the "in-school" factors with some of the "out-of-school" factors in an educational environment, was re-examined.

Although Keeves' research focussed on the factors which might influence pupils' *achievement* in science, it was decided that the main research questions (see Introduction to this Chapter) could possibly be addressed by concentrating on the 'attitudinal' and 'process' dimensions which were central to Keeves' framework. The possible influences of the 'parents' attitudes and ambitions'[15] together with the pupils' 'occupational aspirations' (or career choices) and the 'processes of the home' provided ideas for some of the "out-of-school" factors which could also be examined as possible influences on pupils' attitudes to school science. Whilst acknowledging the importance of the various influences which social class (see Kelly, 1986) and ethnicity have on family income, and the complex relationships between social class and the type of school selected by parents for their children (Keeves' 'structural dimension'), these factors were outside the main focus of the current research.

[15] Data on practices in the home expected to influence performance at school were obtained by interviewing the pupils' mothers.

4.7 Tentative proposals for the study

To answer the questions posed in the research study, and with reference to comments in the literature (Chapter 3), it was proposed that data be collected, via questionnaires, from a cohort of primary pupils in Years 5 and 6 who would transfer to a common secondary school for Years 7 and 8. This would involve a 4-year period of fieldwork (one-year longer than most of the pre-National Curriculum research) and provide data both pre- and post-transition between primary and secondary[16] phases. Additionally, using the model provided by Keeves (1975), information would also be collected via questionnaires (preferably during Year 6 i.e. during the second year of the study) on their parents' attitudes to, and experiences of, science and the parental involvement with their child in "out-of-school" and home-based activities (see 4.2).

Before approaching appropriate schools about their possible participation in the exercise it was important to formulate some more precise ideas concerning:

(1) the most convenient timings of the data-gathering exercise;
(2) the nature of the information which would be sought from the pupils, and
(3) the time commitment which would be required from schools if they agreed to participate in the study.

Regarding (1) it was assumed that, for each of the four years, a convenient point for data collection would be as late as possible in the summer term i.e. when the curriculum coverage, together with any school-based tests, for that school year would have been completed. Bearing in mind the constraints on the timetabling in most schools, and the heavy commitments of teaching staff, it was felt that the time allotted to each of the annual information-gathering exercises should be kept to a minimum – ideally a maximum of one teaching period (about 30 minutes in the primary phase and 1 hr. in the secondary phase).

It was proposed, therefore, that written questionnaires be administered towards the end of the summer term in each of the 4 years of the study starting with Year 5 in the latter half of the summer term 1995. No demands would be placed on teaching staff except permission to administer, at some mutually convenient time, the written questionnaires to the pupils. The comprehensive school would not be involved until the summer of 1997 when the original cohort of Year 5 pupils would have completed almost a full academic year in their new secondary environment.

[16] Most of the pre-National Curriculum research had been carried out solely in the secondary sector.

4.8 A pilot study

Before any approaches were formally made to schools, a pilot questionnaire (Appendix 4.6) was issued, with the permission of the Headteacher, to 60 (Year 7) children in a secondary school in which the researcher was teaching at the time. The aim was to see how much information could be gained directly from the pupils about their parents' background in science and their involvement, with their children, in scientifically-orientated "out-of-school" experiences. It was also a chance to establish how long children of this age could reasonably be expected to write freely about their personal attitudes to, and knowledge of, 'science'.

The pilot questionnaires (see extract at Appendix 4.6) were hand-written so as not to create an 'examination' atmosphere and the maximum period allowed within the constraints of the timetable was 35 minutes, including introductory explanations and assurances of confidentiality (no names or identifying /codes were put on these papers).

Whilst most of the direct questions concerning the pupils' <u>own</u> experiences raised no problems, it was quite obvious that these children, even in Year 7, had little knowledge about their parents' occupations and even less information about their parents' backgrounds in science (see Keys, 1987). This provided re-inforcement that the information on these key issues would need to be obtained from the parents themselves. (When, eventually, final approval was given for the proposed study to proceed, the primary Headteachers gave permission for coded questionnaires to be sent to the pupils' parents[17] during the Spring term of 1996 – see 4.5).

Several other questions, e.g. whether or not either, or both, parents had attended college or university and, if so, what was the subject of their degree, appeared to be too complicated and, in some cases, too ambiguous to be meaningful. The data were collated on a spreadsheet and kept for reference; no student could be identified from these data.

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[17] the person who has shared, or main, responsibility for the child's welfare (see Chapter 9).

4.9 Selection of the pupil cohort for the study

In order to reflect the local pattern of state-funded secondary education a tentative list was drawn up of mixed, comprehensive schools which might be considered for the secondary phase of the proposed study. There were five factors which needed to be considered:

1. The secondary school should be in an area where the two-tier system of primary and secondary schools was in place (i.e. not a three-tier system of first, middle and upper schools) and the age of transition between primary and secondary phases should take place between Years 6 and 7 (i.e. at about age 11).
2. In order to cover a wide ability range, and to allow analysis of gender issues, the secondary school would need to be a mixed comprehensive school with boys and girls represented in approximately equal proportions.
3. The comprehensive school should be located as near as possible to the participating primary schools (so that the children did not move, on transfer, into a significantly different cultural environment). The need for a single secondary school was defined by the need to minimise the number of variables, a high transfer rate to a single secondary school would minimise the "loss" of pupils after Year 6 as pupils elected to move to a variety of secondary schools.
4. There would need to be at least two primary schools involved, a single primary school would be unlikely to provide a sufficient number of pupils in any one year group to generate sufficient data for this type of study.
5. In order to minimise the amount of travelling time which would be needed to organise the study, the area in which the fieldwork was to be conducted should ideally be as close as possible to the researcher's home base.

Using the five criteria above, an appropriate secondary school, with four local partnership schools, was identified. These five schools benefited from a close relationship between the primary and secondary phases (arrangements for the primary children to participate in pre-transfer visits to the secondary school had been in place for several years) and, overall, about 85% of the children in these primary schools transferred to the local comprehensive in this area.

4.10 Approaches to schools

In the autumn of 1994, tentative approaches (by telephone and personal contact) were made to the Headteachers of the four primary schools and the Head of Science at the local comprehensive school (where the researcher had previously taught) in the selected area of

Oxfordshire. The summer term of 1995 was suggested as the earliest possible starting date for the longitudinal study. Initial responses were quite positive in three of the four primary schools approached; the fourth – although interested in the aims of the study - was unable to proceed further because of numerous staff changes including the imminent change of Headteacher. The secondary school, which also accepted a minority of children from several small, rural primary schools, showed support for the exercise but was particularly concerned that no demands should be made on teachers' time and that any interruption of pupils' lessons should be minimal. On this understanding, the Head of Science agreed in principle to allow the researcher access to the children in Years 7 and 8, subject to more detailed information being made available.

More information on the aims of, and outline proposals for, the study was then dispatched to the primary Headteachers at the participating schools (and the Head of Science at the comprehensive school). Formal acknowledgement was made in the letter that the proposed fieldwork would be carried out as part of a submission for a higher degree of Oxford Brookes University; parents were notified through a presentation at each of the primary schools' Open Days. The information on pupils would be coded and no individual pupil would be identifiable except by the researcher.

4.11 The pupil cohort and their schools

Two of the three primary schools which agreed to participate in the study were in close proximity to each other and no more than a few hundred yards from the local comprehensive; the third school was slightly further away, about half a mile from the other schools. All three schools therefore took children from the same locality, a pleasant small town about 8 miles from Oxford. One of the schools (UN) was Roman Catholic aided; the other two (OL and XL) were typical county primary schools. Teaching in Schools UN and XL was conducted in the normal vertical year groupings (one class and two classes per year respectively) but, at School OL[18] Years 5 and 6 (as well as Years 3 and 4) were taught together in parallel year groups. It was anticipated that, with the co-operation of three primary schools in the area, over 100 pupils should be available to take part in the study (see Table 4.1).

[18] Thirty-seven children in the Year 5 cohort were distributed between 3 Year 5/6 classes with teachers Mrs I, Mrs N and Mrs U.

Table 4.1: Anticipated sample size (Year 5 in three primary schools)

School	Teacher	Number of pupils in Year 5 class
OL	Mrs. I	OLI 12
	Mrs. N	OLN 11
	Mrs. U	OLU 14
Total (OL)		37
XL	Mr. D	XLD 27
	Mrs. I	XLI 25
Total (XL)		52
UN	Mrs.W	UNW 32
Total (UN)		32
Total all classes		121

It was anticipated, however, that there would be some attrition in the Year 7 cohort, as some pupils moved out of the area (or chose other secondary schools); losses between Years 7 and 8 would probably be minimal. Whilst attempting to design a study which would produce sufficient meaningful data, account had to be taken of the amount of fieldwork which could realistically be achieved by a single researcher bearing in mind the time constraints imposed by the 'gatekeepers'[19] on the researcher's access to the children.

4.12 Data collection

4.12.1 Questionnaires

Questionnaires were to be used for the assessment of pupils' attitudes to science at the end of Years 5 to 8 and also to elicit information from parents about their experiences of, and attitudes towards, science. Following visits to each of the primary schools, dates were suggested when these questionnaires might be administered.

The quantity of data to be collected and analysed would be determined by the number of pupils eventually taking part in the study (see section 4.11), the time constraints on the completion of each proposed questionnaire and the attention spans of the pupils involved. Although the research literature places much emphasis on the design and administration of questionnaires (see Oppenheim, 1966 and Henerson et al., 1987), relatively little has been written about questionnaires and their limitations for upper primary age children (see Galton and Simon, 1980).

[19] defined by May (1993, p.42) as "those who control access to the information which the researcher seeks"

The first (Year 5) questionnaires were, therefore, designed with reference to the step-by-step procedure recommended by Henerson et al. (1987). Feedback from the administration of the Year 5 questionnaires informed some design aspects of the later questionnaires; the choice of individual questions appropriate to each stage of the research is discussed in the appropriate sections of Chapters 5 to 10.

Henerson et al. (1987) suggested that the front page should be succinctly worded and contain as few questions as possible, allowance should also be made for any non-applicable questions to be skipped by the respondents. Dey (1993) also recommended that a good questionnaire should also make use of "funnelling" techniques i.e. placing a general, non-threatening question earlier in the sequence than the questions requiring more specific responses.

Commenting on children's short attention span and their possible difficulties in understanding the question (especially if the vocabulary is too sophisticated), Henerson et al. (1987) suggested that questionnaires designed for young pupils needed to be brief; ideally questions should not use more than 20 words and that the words should not consist of more than 3 syllables. They also recommended the use of positive statements (to which the recipients would indicate the strength of their agreement or disagreement). Oppenheim (1966, p.167) suggested the inclusion in questionnaires of some 'scoring reversals'[20] i.e. the recipient is asked to score the strength of their agreement with *unfavourable* statements.

Commenting on the scoring methods used in attitude measurement, Henerson et al. (1987) suggested that, instead of using the 5-point scale, the responses could be given pictorially e.g. as 'happy faces' ☺. This suggestion, together with scaled responses in words (see Mortimore et al., 1988) was taken up for each of the pupils' questionnaires over the 4-year period.

The first, rejected, pilot questionnaire had indicated that brevity and simplicity were going to be essential issues if a questionnaire for younger (Year 5) children was going to provide meaningful responses. Taking account of the recommendations in the literature (Henerson et al., 1987 and Oppenheim, 1966) it was essential that the format was in a style to which

[20] this strategy was later adopted for the Year 8 questionnaire.

the children were accustomed. Earlier examination of the written material (particularly worksheets) to which the Year 5 children were normally exposed, suggested that they were generally handwritten and that they often contained simple diagrams and so, for this age group, a single-sided, hand-written, format was adopted for the first questionnaire.

A draft questionnaire, drawn up in consultation with the deputy Headteacher of one of the participating primary schools, was then offered to each of the six class teachers of Year 5 children for his/her approval and for advice on vocabulary and topic content. On the next visit to each of the other primary schools, the questionnaire was then offered to a small group of children for "readability". There appeared to be no problems and the teachers reported that, whilst a few children had below average reading ages, there were no non-readers in the cohort; neither were there any children for whom English was a second language. When the questionnaires were actually issued, assistance in recording the comments was given in a very few cases (either by the researcher or a Learning Support Assistant).

In an attempt to minimise the potential errors brought about by treating a list as if it were in rank order, a simple format for the Year 5 questionnaire (Appendix 4.1) was devised which used a flower 'petal' design, the subject title (as conveyed to the pupils) of each topic being placed into each 'petal' to act as a prompt. In Schools UN and XL, six topics were covered during Year 5 but in School OL (where Years 5 and 6 were taught in the same class) only five topics were covered during that year and the number of 'petals' was therefore reduced to allow for this. With this exception, the overall format for the questionnaires for each primary class was identical except that, in some instances, there was a slight variation[21] between the three schools in the phrase used to identify a particular topic area. Each school therefore had a questionnaire which was tailored to match the topics covered within that school; this proved to be an appropriate way of minimising queries and of refreshing the pupils' re-call of the projects which they had undertaken during the year. The only other variable was the use, to facilitate data sorting, of different colours of paper for different classes within each of the primary schools.

[21] e.g. in School OL, "Planet Earth" covered the same curriculum content as "Earth in Space" in School XL.

4.12.2 Tape-recordings

In view of the time constraints, it was thought feasible to interview six pupils (three boys and three girls) from each Year 5 class (i.e. a maximum of 36 pupils) in the first year of the study; it was anticipated that this number would be reduced in the secondary phase as some pupils moved to secondary schools not participating in the study. Despite the potential problems of dominance of one pupil over the other, the pupils would be interviewed in ability-matched[22] boy-girl pairs.

Useful practical information on conducting interviews in non-threatening environments, together with recommendations about aids to re-call, the order and format and length of questions, was derived from Sudman and Bradburn's book (1983). Drever's (1995) article on the preparation of semi-structured interview schedules, published after the initiation of the study, was also consulted for guidance on the schedules for use in the secondary phase. Drever emphasised the importance of including general, non-threatening questions at the start of the schedule and commented (p.65) that, with children, an interview could be regarded as an "oral questionnaire" or "a dialogue between two people".

> "....in a semi-structured interview you create a structure mapping out the topics to be covered, control the interview to ensure coverage and probe for reasons."
>
> Drever (1995), p.65

Powney and Watts (1987) noted that the interview session itself was only one aspect of the whole process of interviewing. As well as the planning, organisation and recording of the interviews, transcribing, analysis and reporting of the interviews was also involved. These aspects have received relatively little attention in the literature. They commented on the fact that the detailed discussion by Tizard et al. (1980) which followed the publication of "15,000 Hours and their Effects on Children" (Rutter et al., 1979) made only *one* reference to interviewing.

The processing of qualitative data or 'illustrative quotations' (Oppenheim, 1966, p.235) is notoriously time-consuming. May (1993, p.104) reported that a one hour tape-recording of verbal responses may consume 8 to 9 hours of processing time. Any semi-structured interviews undertaken in the proposed study would necessarily have to be brief, probably no more than 10 minutes duration per pupil. If these interviews could not take place during

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22 as recommended by the class teacher

lesson time, it would be suggested that they could possibly be arranged in lunch-breaks or after school, by mutual consent with the children. Parents of the participating pupils would be notified by letter at the start of the study about its objectives and the involvement of their child in the information-gathering exercises. (Only the data for those children whose parents had positively elected to respond to the parental questionnaire were included in the final cohort analysis). Anonymity would be preserved and all pupil data would be coded. A summary of the findings would, in due course, be made available to all participating schools.

4.12.3 " Mini-essays"

At the end of the primary phase, the pupils were to be asked to contribute a "mini-essay" (see 4.2) which might provide some additional qualitative information not elicited by the questionnaires. It was assumed that it would be easier to administer any requests to provide additional information in the primary phase rather than in the secondary phase when the cohort pupils would be dispersed, together with non-cohort pupils, among several different teaching groups. It was decided, therefore, that the request for such an 'essay' (Appendix 4.7) would be made on the same occasion as the request to complete the written questionnaire during the summer term of 1996. Acknowledging that there would probably be a wide range of literacy skills within this year group, it was felt that the completion of a 'mini-essay' should be seen very much as an 'extension' activity rather than an obligatory part of the questionnaire completion exercise.

4.12.4 Parental questionnaires

Some of the additional research questions concerned the possible relationship between the parents' *attitudes* towards, and *experiences* of, science and the pupils' attitudes to the subject. Appropriate questions posed through questionnaires[23] were sent, via the school, to the parents; these questionnaires would also attempt to elicit whether there were any links between the degree of parental involvement with their child in scientifically-orientated "out-of-school" activities and the pupils' attitudes to science.

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[23] The format and the rationale behind the questions asked in the parental questionnaires (Appendix 4.8) are detailed in Chapter 9.

4.13 Data handling

The SPSS (Statistical Package for Social Scientists) software (initially version 3.11 later, version 10) was recommended for the processing of attitudinal data.

The intervals on attitudinal scales are considered to be unequal and Kinnear and Gray (2001, p.10) commented on the controversy in the literature about the use of non-parametric tests instead of parametric *t*-tests with data based on such scales. They quoted Howell (1997) who emphasised the robustness of *t*-tests and suggested that, provided the data showed no contraindications (e.g. presence of outliers, marked skewness, significant disparity of variances or sample size) a *t*-test should be used. Where a *t*-test might be inappropriate, non-parametric (Mann Whitney) tests of significance should be considered despite their lack of power[24] to reject the null hypothesis should that be false. Unless otherwise indicated, therefore, parametric *t*-tests for the significance of the difference of paired or independent sample means were used.

ANOVA procedures (Kinnear and Gray, 2001, p.11) were used to examine any links between the pupils' attitudes and several variables such as interest in sporting activities etc. Spearman's rank correlations were used for the examination of measures of association of variables such as attitude scores or, where the sample size was very small, Kendall's tau (Kinnear and Gray, 2001, p.259) was used. In the case of dichotomous variables, e.g. gender, chi-square tests were employed to compare frequency distributions. In the final stages, step-wise multiple regression procedures (Kinnear and Gray, 2001) were used to identify the predictor variables.

Consideration was given at this stage to the use of software packages designed for the analysis of qualitative data[25] such as The Ethnograph, Ethno v. 2.1 and Nudist v. 2.3 (Stanley and Temple, 1993). Trial runs using these packages on other data provided by Oxford Brookes University indicated that they were not necessarily superior (in time saving or in depth of analysis) over the use of traditional methods of coding and analysis. Drever (1995) commented that, whilst computer-based software packages were valuable when large numbers of interviews have to be processed in a routine way, the use of such packages often meant that the interviewer tended to lose the "feel" of the data.

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[24] Power = probability that the null hypothesis, if false, will be rejected (Kinnear and Gray, 2001, p.147)
[25] 'Non-numerical unstructured data indexing, searching and theory-building' (Robson, 1993, p.390).

It was decided, therefore, that the SPSS software, together with the current version of Microsoft "Word", would enable the 'cutting and pasting' and coding operations to be completed appropriately. It was anticipated that the pupils', and possibly some of the parents', responses on questionnaires would be presented in the form of short phrases or single word answers rather than as several sentences of text. Similarly, it was expected that the responses in the semi-structured, tape-recorded interviews were likely to be fairly brief.

Some of the problems associated with the coding[26] of qualitative data have been discussed by May (1993) and Oppenheim (1966). Oppenheim (1996, p.227) offered suggestions about the handling of data from open answers using a coding frame and agreed that it was not easy to design a coding frame which would "do justice to the data". When the collection of data was completed, it was clear that the children's answers on the questionnaires were concise (probably due to the limited space available) and the responses in the tape-recorded interviews were rarely longer than 2 or 3 sentences. Since the pupils' responses were to relatively simple, concise questions, the qualitative data generated from the study were relatively easy to code[27] into first-level and second-level (Robson, 1993, p.385) concepts or themes and were then examined for frequency of citation (with respect to gender).

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[26] "The purpose of coding in surveys is to classify the answers to a question into meaningful categories, so as to bring out the essential patterns" May (1993, p.76).

[27] see Robson, 1993, pp.385-386.

4.14 A timetable for the study

The timetable and methodology for the whole exercise could now be summarised as:

Table 4.2: A timetable for the study

Year	Date of survey	Questionnaires	Tape-recorded interviews[28]	Mini-essay	Parental questionnaire
Year 5	1995	√ Approximately 100 pupils (from 3 primary schools)	√ 36 pupils (6 pupils, 3 boys and 3 girls, from each of 6 classes)	X	X
Year 6	1996	√ as 1995	√ as 1995	√	√ (Spring term)
Year 7	1997	√ cohort (about 85) who will have transferred to the participating secondary school	√ cohort (about 30) who will have transferred to participating secondary school	X	X
Year 8	1998	√ cohort who are in participating secondary school	√ cohort who are in participating secondary school	X	X

28 Interviewees were nominated by the class teacher to reflect higher, average and lower ability levels. (When nominating a pupil, the teacher had also been asked to take into account whether or not the pupil was likely to continue his/her education at the secondary school which was to be included in the longitudinal study).

4.15 Implementation of the study

At the start of the fieldwork in July, 1995, 108 pupils[29] completed the questionnaires (see Table 4.3).

Table 4.3: Composition of the cohort[30] at July, 1995

School	Class	Boys		Girls		Total
		Year 5	Year 6	Year 5	Year 6	Year 5
OL	I	4	9	8	8	12
	N	4	6	5	9	9
	U	5	6	7	6	12
XL	I	13		9		22
	D	13		11		24
UN	W	17		12		29
TOTAL						108

All the classes had been visited on at least two occasions and the researcher had been able to observe science investigations in these classes at an earlier stage. One of the major problems was the difficulty, due to constraints on the schools' timetables and the researcher's own teaching commitments, of establishing mutually convenient times for the administration of the questionnaires in six different classes in three different schools. Eventually a timetable was agreed for the completion of the questionnaires during the last week of June and the first two weeks of July (1995).

4.16 Data collection and evaluation 1995-1998

4.16.1 Questionnaires

Year 5

When the first questionnaires were issued, in July 1995, the pupils in each of the six classes were given short (10 minute) presentations about the survey and questions were invited. In the event, most of the questions raised practical issues (for example whether a pen or pencil was to be used) rather than any queries about the questions themselves. Emphasis was placed on the fact that this was *not* a test and that the pupils' Headteachers had fully supported the study. A few simple comments about teachers' wishes to learn about what made a 'good' lesson in the pupils' eyes (and, equally, what things did not work) seemed sufficient to convey the objectives of the study to these quite young children.

[29] Pupils at the participating schools but absent when the questionnaires were issued are excluded.

[30] "A cohort is defined as those people within a geographically or otherwise delineated population who experienced the same significant life event within a given period of time" (Glenn, 1977).

The use of 'happy faces' ☺ (Henerson et al., 1987) seemed to remove any potential confusion about the '1' ('disliked a lot') → '5' ('liked a lot') scoring system; the pupils were asked simply to give their responses according to which 'face' they felt best represented their 'feelings' about each topic. ('Happy faces' were also incorporated into the subsequent questionnaires).

The pupils in the primary schools completed their written questionnaires in virtually identical (classroom) situations, usually within the same week and within the same time span (20 minutes). The views of the five children who did not, for a variety of reasons, give written comments were dictated to the researcher. Only in a very few cases were there indications that some of the questions towards the end of the sheet(s) had not been answered because of lack of time. Without exception, the Year 5 children co-operated well and an examination of the questionnaires showed that there were only three children who had filled in the responses in a rather casual manner. Because of the variation in curriculum planning in the (three) different primary schools, it was possible that the ease with which different pupils could re-call a particular project varied. A pupil who had studied a particular topic in the autumn term would possibly be able to remember less detail about the topic than a pupil in another class who had just completed it in the early weeks of the summer term. This was outside the researcher's control; it had to be assumed that the pupils' attitudes had not been significantly affected by the passage of time. In an attempt to minimise the differences, a few minutes of each of the introductory sessions had been devoted to a review with the children of what had been covered during the year in each of the topic areas. The rationale for the inclusion of the various questions in the Year 5, and later, questionnaires is included in the appropriate Chapters on the analysis of the data.

<u>Year 6</u>

The design of the Year 6 (word-processed) questionnaire was informed by the evaluation of the Year 5 questionnaire and, in order to facilitate the students' re-call of topics covered during the year, the subjects covered by each school were mentioned by name (for example 'Victorians' or 'Tudors') in the design.

By now the pupils were more aware of the borderline between 'science' and 'non-science' topics and so the simple question: "Compared with other subjects, how do you feel about science?" was now fairly meaningful. It is perhaps interesting to note that in Keeves'

(1973) study in Australia, it was felt that because pupils 'had not been taught science in a systematic way' at elementary school (Keeves, 1973, p.448), their attitudes to science were not assessed until the end of the first year at secondary school (i.e. Year 7). Six pupils who had completed questionnaires in Year 5, were absent when the Year 6 questionnaires were administered and, because of the inaccuracies created in a longitudinal study when the data are incomplete, the data from these six pupils were not included in the quantitative analyses. The number of pupils completing both Year 5 and Year 6 questionnaires was, therefore, reduced to 102.

The questionnaires also included open-ended questions on 'favourite' subjects and 'out-of-school' interests, hobbies and activities.

Year 7

In the event, a lower than expected number of the 102 pupils in the Year 6 cohort transferred to the comprehensive school in September 1996. (Only 71 of these 102 pupils, for whom Year 5 and Year 6 data were available, were also present when the questionnaires were administered in 1998 at the end of Year 8; again absences from school were due almost entirely to participation in activity weeks or similar). The data analysis for the secondary phase was, therefore, based on this reduced cohort of pupils. This problem of attrition is discussed by Menard (1991, p.36) who quoted attrition rates as high as 55% in some studies. Whilst it was possible to trace most of the pupils who dropped out of the study at various stages, particularly at the end of Year 6, the introduction of additional variables (particularly the transfer to a different secondary school) was not the intention of this longitudinal study.

On entry to the comprehensive school the Year 7 pupils from the three participating primary schools were joined by 85 pupils (from seven other primary schools) and placed into one of seven Tutor Groups. Because of time-tabling constraints, with the support of the Head of Lower School Science, the Year 7 questionnaire was issued simultaneously to all 156 pupils in the lecture theatre; this allowed the data to be separated into 'cohort' ($n=71$) and 'non-cohort' ($n=85$) data for comparative purposes. The completion of questionnaires was preceded by a brief illustrated talk to the pupils to inform the non-cohort pupils (and to remind the cohort pupils) of the purpose of the study and of the steps being taken to ensure confidentiality.

Year 8

Although there were many absentees due to end-of-term 'activity weeks', the questionnaire was offered to the entire year in their science teaching groups. This meant that it was again possible to compare the responses generated by both the cohort, and non-cohort, pupils within the year group. As with previous years, the rationale for the questions included in the questionnaires is given in the appropriate chapter on data analysis.

4.16.2 Semi-structured, tape-recorded interviews

In Year 5, semi-structured, tape-recorded interviews (Appendix 4.9) were undertaken (in mixed pairs) with 36 pupils (see Table 4.2). The pupils were assured of confidentiality and they did not need to give their names if did not wish to do so; individual pupils were coded according to school class and number on the register.

The Year 5 children were very positive about their tape-recorded interviews - possibly because it was an opportunity to 'escape' from class lessons for a short while – and most had plenty to say. It was anticipated that the interview schedule for six children (in 3 pairs) would be achievable within the time of a normal primary lesson but, for a variety of reasons, this was not always so and a class had to be re-visited to complete the schedule. During the summer term there were many disruptions to the normal timetable – school trips, sports days and other end-of-term activities. Some primary children were out of school on early holidays and there were, inevitably, some absences for medical, or personal, reasons.

Whilst all the class teachers were supportive of the interviewing exercise, the main problem proved to be the actual location of the interview. When no separate, quiet room was available, the background noise from activities inside the classroom was sometimes a cause of distraction and the recordings were, inevitably, of inferior quality.

By Year 6, four pupils (three girls and one boy) were absent when timetabled for their tape-recorded interviews (Appendix 4.10) and the number of recorded interviews fell to 32. Again, because of space limitations, some of the interviews were interrupted by pupil movements and three of the recordings were of very poor quality. In the secondary school environment, 31 pupils gave interviews, but it became increasingly difficult to find appropriate times to conduct these interviews - many pupils were involved in lunch-time activities or went home for lunch. During the last week of term, the Head of Science allowed some interviewees to be taken out of science lessons but, by this time, several had gone on activity weeks or were involved in other activities. The problems with finding suitable locations for interview continued at the end of Year 8 and the number of interviewees fell to 20 (11 girls; 9 boys). Although there had been no obvious dominance by one student over another when interviews were conducted in pairs, there had been some slight confusion concerning the source of the response when transcribing the interviews. The lower number of potential interviewees in Year 8 meant that most of the pupils could be interviewed individually without significantly increasing the time committed to the fieldwork.

4.16.3 "Mini- essay" (Year 6)

Mini-essays had been suggested (see section 4.12.3) as an extension activity for the Year 6 pupils and they were issued together with the questionnaires. In order that the task would not seem too daunting, the space in which the 'mini-essay' should be contained was defined - see Appendix 4.7 - and the pupils were told that they could include drawings as well if they wished; in one case, a boy (UNW22) simply drew some test tubes and what appeared to be a laboratory-based activity but no text was submitted.

In these circumstances it would be reasonable to expect that, for each pupil, there should be a high level of consistency between the two documents and so all the submitted 'mini-essays' were checked for consistency with the written questionnaires. In only six instances were there any minor differences between the comments on the questionnaires and those on the 'mini-essays' and these were generally only minor points of detail (e.g. the attitude score awarded to a particular module on the written questionnaire did not exactly agree with the comments made in the 'mini-essay'). Examination of the "mini-essay" documents, however, showed that in only a very few instances was any additional information provided which had not been documented in the Year 6 questionnaires. However, some of the details which contributed explanations for the pupils' attitudes are included at appropriate points in Chapters 5 to 7.

4.16.4 Parental questionnaires

In order to ensure that all the possible levels of educational background were likely to be covered by the wording of the questionnaire, a draft questionnaire was piloted with 20 parents (age range: 27-60) who came from different educational backgrounds but who were not involved in the study. Following some minor re-drafting, the coded questionnaires (Appendix 4.8) were dispatched to parents, via classroom teachers, in the

Spring term of 1996. The percentage of returns (see Appendix 4.13) was generally higher from the smaller classes; whether this variation in output was due to the greater diligence or enthusiasm of the class teachers, the ability and enthusiasm of the pupils, or simply the easier class organisation and management inherent in smaller classes, it is not possible to specify.

4.17 Extension of the study to incorporate some Year 9 data

In the autumn term of 1998, the researcher was appointed to a teaching post within the secondary school where the fieldwork had been conducted during the summer terms of 1997 and 1998. An opportunity arose to incorporate some specific questions about attitudes to science in Year 9 within a questionnaire (Appendix 4.5) being developed to review current practice in teaching and learning at KS3. The primary purpose of the questionnaire was to elicit pupils' views on certain "in school" factors such as the value, for revision purposes, of their current text books and the usefulness of a series of pre-test revision lessons. Within the school, there was also a need to re-consider whether gender issues in science were being adequately addressed and, due to constraints on capital expenditure, whether appropriate resources were available for yet more curriculum changes. These questionnaires were issued by individual science teachers to their Year 9 groups and, in the researcher's group, the change of role from 'researcher' to 'teacher' passed without comment (see Chapter 11).

Comparison of the completed questionnaires from the researcher's group with those derived from other Year 9 groups did not indicate any significant differences in the responses. The analyses of data from the cohort pupils who had participated in the research in Years 5 to 9 are included, where relevant, in the following Chapters. Chapter 5 discusses the findings of the research study on pupils' attitudes to the content of school science and specifically the gender differences in attitudes to the physical and biological sciences.

Chapter Four: Methodology for the study

4.18 Summary

The nature of the research questions dictated the use of a longitudinal study. The research literature suggested that the most appropriate method of data collection was by annual questionnaire to the pupils over the 4-year period. The questionnaires were intended to provide both quantitative and qualitative data; they were supplemented, each year, by semi-structured, tape–recorded interviews and, in Year 6, by some "mini-essays".

In Year 6, questionnaires were also issued to parents to elicit information on their attitudes towards, and experiences of, science and to investigate whether there was any link between these attitudes and their children's attitudes to school science. Attempts were also made to seek out parental involvement in various "out-of-school" and home-based activities e.g. 'tinkering' and to relate the parental involvement in such activities to various measures of the children's attitudes to science.

Attitude measurement utilised Likert-type scales (with 'happy faces' used to support the numerical values). Where possible, verification of the questionnaire responses with the transcripts of the tape-recorded interviews was undertaken; some of the errors inherent in attitude measurement were discussed.

The rationale for the selection of the pupil cohort for the study, using three primary schools and one comprehensive, together with the design and administration of the questionnaires, particularly for Year 5, were discussed and a timetable the study was presented. The choice, at the start of the study, of manual coding techniques in preference to computer software packages for the analysis of qualitative data, was explained.

Finally, as the planned fieldwork was drawing to a close, an opportunity was provided to extend the data collection on some specific issues into Year 9 - this is explained briefly at the end of the Chapter.

Chapter 5: "In-school" factors - the content of school based science

Introduction

In order to answer the research questions raised in this longitudinal study (see Chapter 4: Introduction), the data analyses focussed on three main strands:

1: "In-school" factors: attitudes towards school-based science between Years 5 and 8 (Chapters 5, 6 and 7).

2: Pupils' views on some other "in-school" and "out-of-school" factors including transition to secondary school (Chapter 8).

3: "Out-of-school", home-based factors including parental data (Chapter 9).

One of the main questions to be answered was whether pupils who were now exposed to the new compulsory curriculum would demonstrate more positive attitudes to various aspects of school science than those reported in the pre-National Curriculum literature for pupils of same age group. More specifically, were there any improvements in the attitudes, particularly those of the girls, to the physical sciences in the early secondary years?

This Chapter (divided into 4 sections) examines, with respect to gender differences, the pupils' attitudes to the modules in the physical and biological sciences (see sections 5.1 and 5.2 respectively) over the 4-year period – this was one of the key research objectives of the study. The responses towards these two groups of modules are compared in section 5.3. The data for each of the individual modules over the 4-year period were then used to derive a single measure of attitudes over all the science modules and these analyses are presented in section 5.4.

The primary years: Years 5 and 6

In 1995, the written questionnaires (Appendix 4.1) were administered to 108, Year 5 pupils (54 boys and 54 girls). Preliminary visits had revealed that there was some variation between the three primary schools in the way in which the subject content of the science topics was presented to the pupils. In one school (School OL) the teacher clearly identified each topic within the curriculum as either a 'science', or a 'humanities', topic; in another of the schools (School UN) the subjects were simply defined as 'topic work'. For this reason the various topics were identified by name on the questionnaire and, before data analysis, placed by the researcher into two mutually exclusive categories i.e. the physical sciences, or the biological sciences. A similar strategy was adopted for the Year 6 data.

In Year 5 there were four physical science topics: Electricity and Magnetism; Forces; Space and Materials and each of the three primary schools adopted different strategies of curriculum management in order to fulfil the teaching requirements for Key Stage 2. Only one of the three primary schools (School UN) taught Electricity and Magnetism during both Years 5 and 6; the other two schools (Schools OL and XL) chose to concentrate the work on electricity and magnetism in Year 6 only.

In Year 5, each of the three primary schools showed a different approach to the biological science topics. School OL taught biology as a single topic (Living things), School XL divided the content between two topics (The Human body and Plants) and the third school (School UN) deferred the biological science topics until Year 6 - see Chapter 5.2.

In Year 6, there were fewer inter-school differences in subject content and the pupils were now more aware that the individual topics were orientated towards either 'science' or 'humanities'. The physical sciences covered Electricity and Magnetism, Materials and Light and Sound (which was studied, in all three schools, in Year 6 only). The only topic represented in the biological sciences was Living things. The examination of the individual science topic scores in the primary phase, and any conclusions drawn from these analyses, must therefore take account of the fact that, in some cases, the analyses were based on very small samples.

Four boys and two girls from the original cohort of 108 pupils were absent during the administration of the Year 6 questionnaires (Appendix 4.2) and so the Year 5 data for these six pupils were excluded from the analysis for the 'complete' primary phase *(n=102)*, see Table 5.1. Due to the movement of pupils to other secondary schools at the end of Year 6 (and because some pupils did not complete all four annual questionnaires) there were incomplete data over the 4-year period for 31 pupils; only data from 71 pupils[1] were, therefore, included in the final quantitative analyses.

[1] The response data derived from all the 102 pupils who completed questionnaires in Years 5 and 6 (the 'complete' year) were used for comparison with those of the final cohort after attrition *(n=71)*.

Table 5.1: Responses to the questionnaires in both Years 5 and 6

School	Class	Boys	Girls	Total
OL[2]	I	4	7	11
	N	3	5	8
	U	5	6	11
UN	W	13	14	27
XL	D	13	11	24
	I	12	9	21
Total		50	52	102

The secondary years: Years 7 and 8

In Year 7, data were available for 156 pupils including those pupils who had transferred to the comprehensive from non-participating primary schools (see Chapter 4). The questionnaire (Appendix 4.3) included some questions about experiences in the 'new' school for comparison with the responses taken from the original cohort pupils (see Chapter 8) in anticipation of transfer at the end of Year 6. Comparisons were then made between the attitudes of the 71 cohort pupils (from whom data would be available over the complete 4 year period) and the attitudes of those non-cohort pupils who had joined the secondary school in Year 7.

In Year 7, more specialised 'modules' replaced the topic work of the primary school and a 'basic skills' module was introduced which involved a variety of practical experiences in weighing and measuring and an introduction to several items of secondary school equipment. The five physical science modules studied during Key Stage 2 were extended.

One of the main research objectives concerning the "in-school" factors was the comparison of attitudes towards the physical and the biological sciences (Chapter 4, Introduction). Due to comments in the literature (see Chapter 3) concerning the differences in attitudes towards the chemistry and physics components of the physical sciences, particularly the perceived difficulty of each of these sciences, it was decided to explore this further in Year 8 by separating the physical science modules into two mutually exclusive groups of physics and chemistry modules. Although an opportunity was given to make relevant comments on the questionnaire (Appendix 4.4, Question 7), the emphasis of the questions in Year 8 was on the pupils' attitudes towards the sciences of chemistry, physics and biology (see 5.3); no further comments on the *individual* modules were sought.

[2] In School OL, Years 5 and 6 were taught together in 3 classes (hence the small number of pupils in the Year 5 cohort).

The comments which follow are, therefore, based on the data for a cohort of 71 pupils who completed *all four* questionnaires (i.e. in Years 5 to 8 inclusive). The quantitative data (including some derived from non-cohort pupils in Years 5 and 6) for each of the physical science modules[3], together with those for the biological science modules (in Years 5 to 7) are summarised at Appendix 5.1. Data for other groups (i.e. for a complete primary year group before attrition, *n=102*) or for individual schools are also presented, where relevant, for comparative purposes.

Extension to Year 9

In the summer of 1999, the study was extended by mutual agreement with the Head of Science at the secondary school (see Chapter 4) and an opportunity was taken to incorporate some questions which might provide some supplementary information for the longitudinal study into a Year 9 questionnaire (Appendix 4.5). Additional data from this source which are relevant to the longitudinal study are therefore included in the appropriate chapters.

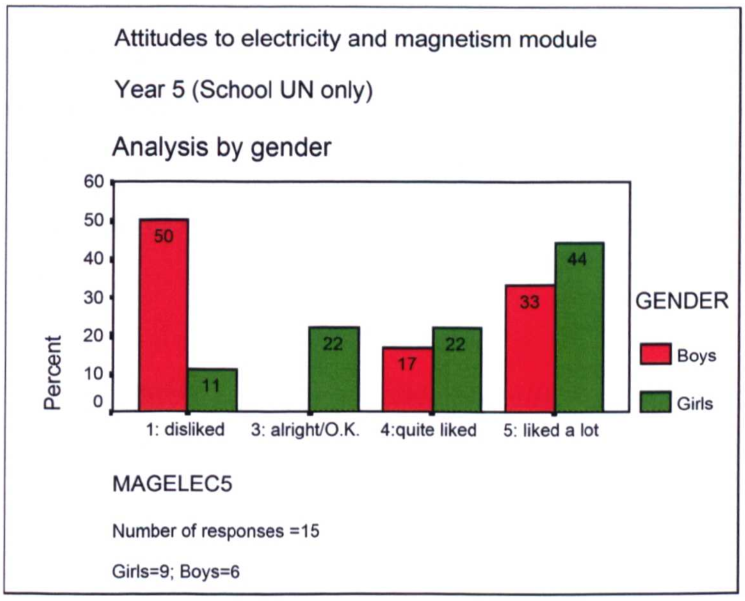
[3] Although primary science was included under the umbrella of 'topic' work, the term 'module' is used in the following comparative analyses from Year 5 onwards.

5.1 Attitudes towards the physical sciences

5.1.1 Physical science modules: Electricity and magnetism

The electricity and magnetism topic was covered by only one of the primary schools (School UN) during Year 5. There were originally 27 responses on this topic, but due to the loss of pupils from the study in Year 7, the data presented below (Fig. 5.1) relate only to the 15 pupils who provided data for all 4 years of the study.

Fig.5.1: Attitudes to electricity and magnetism module: Year 5 (School UN only)



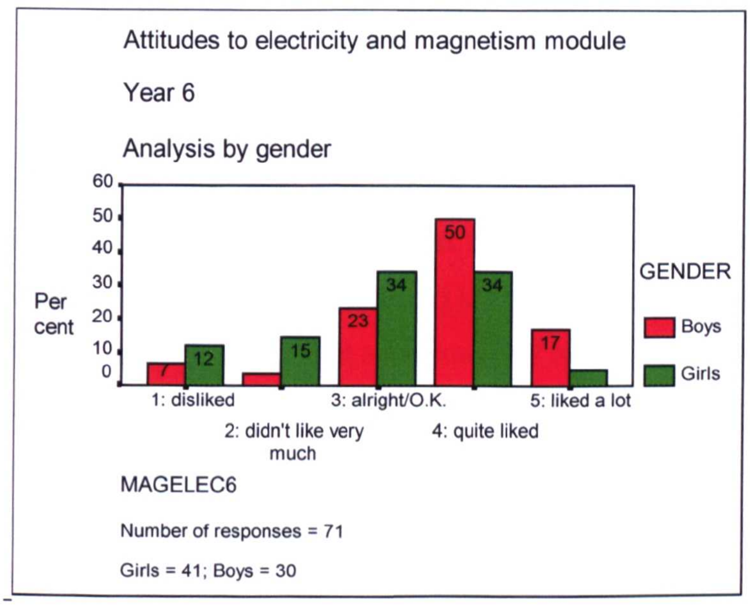
In this very small sample, the mean attitude score for the Year 5 study cohort *(n=15)* was *3.47*. There was no significant difference (Mann Whitney) between the girls' mean score, *3.89,* and that of the boys, *2.83* *(Z=-0.926, p=0.354)* - see Appendix 5.1.

Bearing in mind the inaccuracies inherent in interpreting data from such small samples, the distribution of scores in Fig. 5.1 might suggest a more positive attitude by the girls, compared with the boys, to the electricity and magnetism module. Six of the girls (66%) and 3 (50%) of the boys awarded the module positive scores of '4' and '5'. In this very small sample, the boys' lower mean score (compared with that of the girls) was probably due to the high percentage (50%) of strongly negative attitudes ('1'= 'disliked') held by the boys. In the larger group, i.e. all of the Year 5 pupils *(n=27)* at School UN, a higher percentage (70%) of the boys awarded the modules scores of '4' or '5' and the boys' and girls' means were almost identical – see Appendix 5.1.

Relatively little information was, however, derived from the qualitative responses on the questionnaires concerning the reasons which might support the negative responses; just one pupil (UNW25: a girl) revealed that "it was boring". Out of the 25 pupils (13 boys, 12 girls) who gave positive comments, 16 expanded their explanations to indicate that it was the constructive element ("making and fixing") in the practical sessions which led them to record positive scores e.g. " I liket it because you make it wake (work?)"[1]. Some of the similar comments are given in Appendix 5.2.

All three schools covered electricity and magnetism during Year 6 (see Fig. 5.2). The mean score for the cohort was *3.3*; there was a statistically significant[2] gender difference *(t=2.410, df=69, p=0.019)* between the boys' mean score (*3.67)* and that of the girls' *(3.05)*. Although, as with the Year 5 pupils from School UN[3], just over 10 per cent of the Year 6 girls (from all three primary schools) recorded the lowest score of '1', the percentages of both boys and girls recording the highest score of '5' in Year 6 were much lower than those recorded (33% and 44% respectively) from the single school at the end of the previous year.

Fig. 5.2: Attitudes to electricity and magnetism module: Year 6



However, several pupils commented favourably on both the questionnaires and in the 'mini'-essays, about the practical aspects of "making circuits" and "(learning) to work with lights and batt(e)ries". Six pupils (1 boy, 5 girls) referred in their questionnaires to the practical issues of putting circuits or wires together: "It was good to try and put the socets (circuits?) together" - UNW18, a girl[4].

[1] UNW04, a boy.
[2] The significantly higher *($p<0.05$)* boys' mean score was also reflected in the data generated by the complete Year 6 (*$n=102$*) – see Appendix 5.1.
[3] The only school covering this topic in Year 5.
[4] see also Appendix 5.2.

Just one pupil, (XLI03, a boy), who was enthusiastic about "making circuits with switches and more bulbs" admitted (in his mini-essay) that "the thing that I liked most about sound is list(e)ning to the teacher about vibrations and things" – this was the only comment which linked a willingness to listen with interest and hence a positive attitude towards the module. Out of the 53 written responses from the full year group, only 5 boys and 1 girl identified the module as either stimulating their interest or providing an opportunity for learning.

One boy (XLI05) who had commented on the questionnaire that, whilst he liked "making sercuits (circuits)", the electricity module had involved "to(too) much writing" expanded this theme in his 'mini-essay':

> "Writing information about science I don't like. Writing and writing work. It gets boring as you keep on writing".

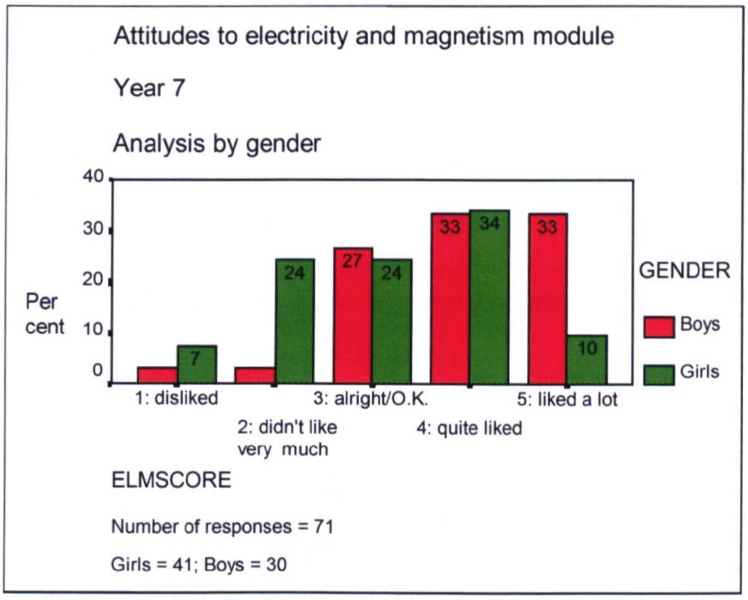
Although this pupil obviously held very strong negative views about the writing content of science lessons, he was the only pupil to comment positively about the value of group work and discussion: "Thinking with groups and sharing ideas. I like talking with people about it"

For the 27 pupils at School UN, who had studied this topic in Year 5, the mean score *(3.78)* for electricity and magnetism in Year 6 was *lower* than that recorded *(4.04)* at the end of the previous school year (see Appendix 5.1). This lower mean score, although not statistically significant[5], might suggest that an element of boredom could have set in with this topic at School UN. However, the mean score *(3.78)* was significantly higher[6] than the mean score *(3.19)* for the Year 6 pupils *(n=75)* in the other two schools (Schools OL and XL) who had *not* studied electricity and magnetism during the previous year. Although there were probably many other "in-school" factors involved in this particular instance, it might have been that, in School UN, a year of re-inforcement in the subject had actually left them with attitudes slightly *more* positive than those of the other cohort pupils.

By the end of the first year in the secondary school, the cohort pupils' *(n=71)* attitudes to this module generally appeared to be quite positive. The percentage of both boys and girls recording each of the scores ('1' to '5') is shown in Fig. 5.3.

[5] $t=-0.456$, $df=14$, $p=0.655$.
[6] $t=2.558$, $df=100$, $p=0.012$.

Fig.5.3: Attitudes to electricity and magnetism module: Year 7



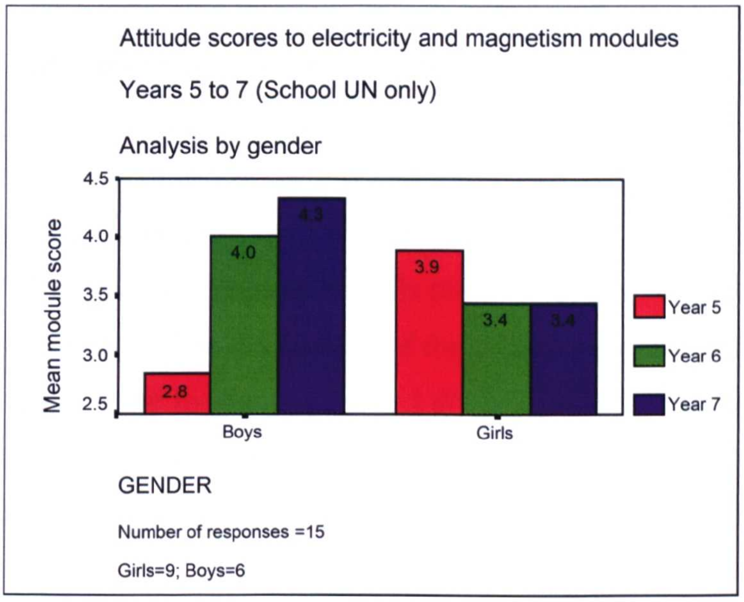
The mean score for the cohort pupils *(n=71)* in all three schools was *3.46;* the boys' mean *(3.90)* was significantly higher *(t=2.881, df=69, p=0.005)* than that of the girls *(3.15)* – see Appendix 5.1.

Most qualitative responses gave little information regarding the specific tasks which had stimulated the pupils' interest. One boy (XLI03) did, however, comment that he "liked making things light up" but this reiterated the many comments made by the pupils on this module in Years 5 and 6 - there seemed to be little new on offer. Two boys (XLD22 and UNW16) and one girl (OLI03) complained that there was "too much writing". Thirteen (31%) of the girls awarded the module negative scores of '1' and '2' compared with only 2 (7%) of boys.

Although, in Year 7, the girls' mean score *(3.15)* was significantly lower *(p<0.005)* than that of the boys *(3.90)* - see Appendix 5.1 – a high percentage of the girls (34%) recorded positive scores of '4' with a smaller percentage (10%) awarding scores of '5' to the topic. The girls' comments ranged from "its fun" (XLI08, score '5') to "It's very boring" (OLI02, score '2') but little information on the underlying reasons which generated these attitudes was, however, given. By Year 7, however, the boys' scores for this topic were particularly high (66 per cent of the boys recorded scores of '4' or '5').

The only pupils in the cohort who had covered electricity and magnetism during each of the Years 5 to 7 were those pupils who had attended School UN. The mean attitude scores for this topic for both the boys and the girls from this school were therefore calculated (sum of attitude score for boys/girls divided by the number of boys/girls) and a comparison, over Years 5 to 7, of these scores is shown in Fig. 5.4.

Fig.5.4: Attitudes to electricity and magnetism modules: Years 5 to 7 (School UN only)



As only 15 cohort pupils (i.e. only those from School UN) had studied this module in Year 5, a fair comparison with the full cohort *(n=75)* in Years 6 and 7 cannot be made but a related samples *t*-test conducted on the data from this very small number of pupils from School UN suggested that there were no significant differences (Wilcoxon Signed Ranks) in the mean attitude scores for this module between Years 5 and 6 *(Z= -0.499, p=0.618)* or between Years 6 and 7 *(Z= -0.322, p=0.747).*

For the small number of pupils *(n=15)* from School UN who had provided data on their attitudes towards the electricity and magnetism modules over the three year period, there was no significant difference (Wilcoxon Signed Ranks) in the boys' *(n=6)* mean attitude scores between Year 5 and Year 6 *(Z=-1.633, p=0.102)* or between Years 6 and 7 *(Z=-0.541, p=0.589).* For the girls *(n=9)*, there were also no significant differences in the mean attitude scores between Years 5 and 6 *(Z=-1.027; p=0.305)* or between Years 6 and 7 (where the means were identical).

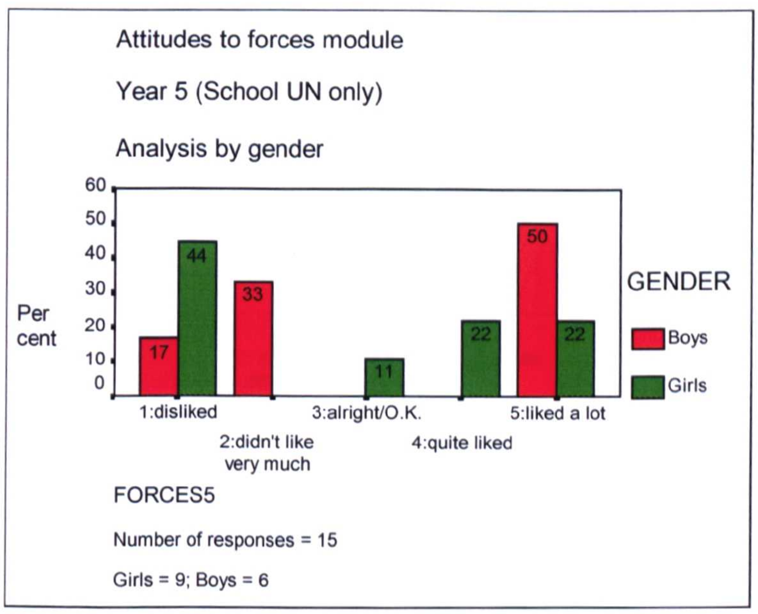
Similarly, for the full cohort of pupils *(n=71)* in Years 6 and 7 there was no significant difference *(t=-1.119, df=70, p=0.267)* between the mean attitude scores for this module. For the cohort boys *(n=30)* and the cohort girls *(n=41)* there was no significant difference between their mean scores in Years 6 and Year 7 *($t= -1.097$, $df=29$, $p=0.282$* and *$t= -0.530$, $df=40$, $p=0.599$* respectively).

Although the quantitative data for this module in Year 5 were taken from one school only, the attitudes (particularly those of the girls) appeared to be fairly positive. The constructive element (i.e. making circuits) was still popular with both boys and girls but whilst the boys' attitudes became more positive in Year 6, the girls' attitudes had already dropped in Year 6 and did not seem to improve on transition.

5.1.2 Physical science modules: Forces and Energy

As with the electricity module, in Year 5 the forces module was only studied by the pupils at one (School UN) of the three primary schools participating in the study and the sample size was very small (*$n=15$*). The distribution of the cohort scores at School UN is shown in Fig. 5.5. The mean score for the topic was *3.00 (SD 1.77)*. In this very small sample, the boys' mean score *(3.33, $n=6$)* was higher than that of the girls' *(2.78, $n=9$)* but there was no significant difference (Mann Whitney) between the means *($Z=-0.858$, $p=0.391$)* – see Appendix 5.1.

Fig. 5.5: Attitudes to forces module: Year 5 (School UN only)

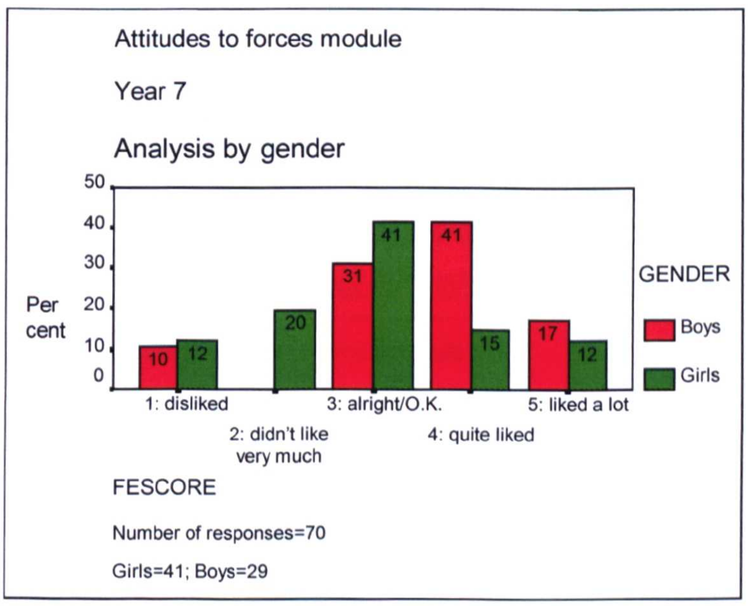


The boys were equally divided in their views; three of the boys appeared to be quite positive about the topic but the other 3 boys recorded negative scores. Data for the full class *($n=26$)*, see Appendix 5.1, suggested that 7 of the boys (54%) held very positive views ('5'='liked a lot'), but there were 4 boys who either 'disliked' the topic or 'didn't like it very much'.

Although one girl in the study cohort did express a view in the middle of the range, the rest of the girls were also equally divided in their views (4 positive; 4 negative). The full Year 5 group *(n=26)* at this school showed a similar distribution of girls' scores at both extremes of the scale; four of the girls (30.8% of the girls) gave the module a score of '5' and four gave the lowest score of '1'. In this larger group, the girls' mean score *(3.15, n=13)* for the forces module was also lower than that of the boys *(3.69, n=13)*; there was no significant difference between the means *(t=0.825, df=24, p= 0.418)* – see Appendix 5.1.

As in the electricity module, the "making and doing" tasks were identified by 12 of the 25 pupils who made comments on their questionnaires e.g. **"**I like it because we made paper airepane" - UNW26, a boy. Other comments are given in Appendix 5.2. Although all three primary schools covered the forces of electricity and magnetism in Year 5, none of the schools extended the work on other forces in Year 6. In Year 7, responses to the forces and energy module were examined for the 70 pupils in the cohort who had studied the topic in both Year 5 and 7 (see Fig. 5.6).

Fig.5.6: Attitudes to forces and energy module: Year 7



The mean attitude score for the forces and energy module in Year 7 was *3.20* (*SD 1.17, n=70)*. There was a significant difference *(t=2.139, df=68, p=0.036)* between the means of the boys' *(3.55)* and the girls' *(2.95)* scores - see Appendix 5.1. Scores, for the girls represented the full range of attitudes '1' (disliked) to '5' (liked a lot); the boys' attitudes ranged from '3' (alright) to '5' with just 10 percent recording the most negative attitudes ('score: '1').

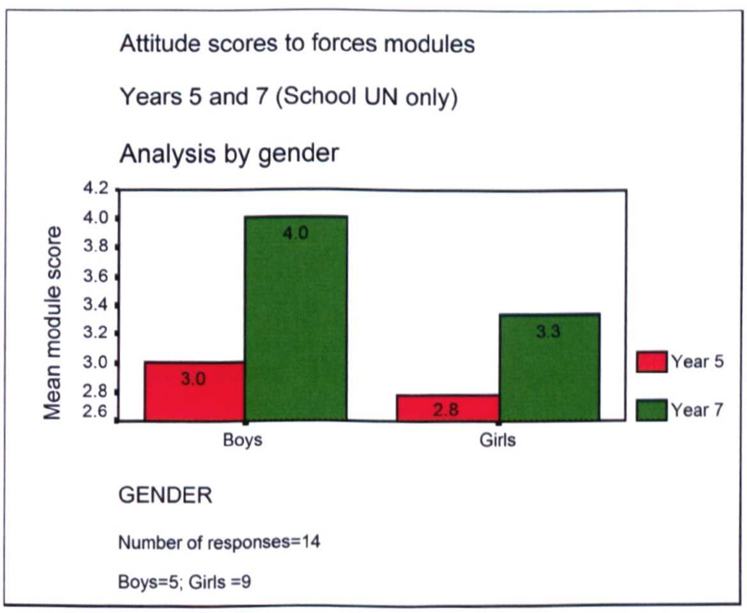
Two of the boys (OLI04 and OLU03), who gave the module the highest score of '5', cited the use of the Bunsen burner as a reason for their score. Generally, little detailed information was given about the reasons underlying the pupils' choices; other responses were spread through the whole range:

> "it was good because you did quite a lot of things" (OLN11, girl)
> "O.K." (OLU09, girl)
> "sad" (XLI09, boy)

One boy (XLD22) and one girl (XLI15) complained about "too much writing". One girl (OLI02) commented that she "couldn't really understand it" and another girl (OLU12) attributed her negative attitude (score='2') to repetition: "boring, I did it in primary school". Apart from the Year 7 boys' comments on the Bunsen burner, there were relatively few comments on any other aspects of this module.

As only 14 of the 26 pupils at School UN who had studied this module in Year 5 also provided responses to the questions about this module in Year 7, comparisons between Year 5 and Year 7 are only made between the mean scores for these 14 pupils – see Fig. 5.7. In this very small sample, both boys *(n=5)* and girls *(n=9)* appeared to exhibit more positive attitudes at the end of Year 7 compared with Year 5 but there was no significant difference (Wilcoxon Signed Ranks Test, $Z=-1.753$, $p=0.080$) between the Year 5 mean *(3.00)* and that in Year 7 *(3.57)*. There was no significant difference[7] between the boys' mean scores in Years 5 and 7, or between the girls' mean scores for the same years.

Fig.5.7: Attitudes to forces module: Years 5 and 7
(School UN only)

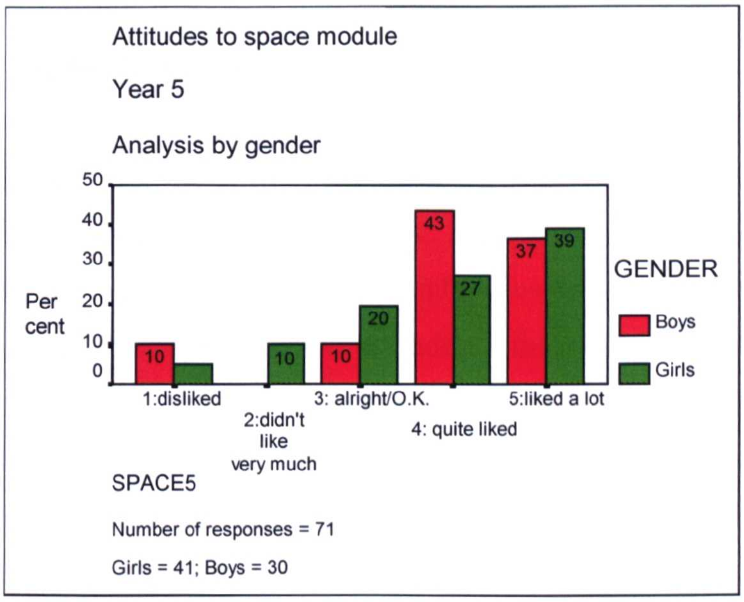


[7] Year 7 mean score compared with Year 5. Wilcoxon Signed Ranks Test: boys' *(Z=-1.225, 0.221)*; girls': *(Z=-1.155, p=0.248)*.

5.1.3 Physical science modules: Space

The space (Planet Earth) topic was studied by all three of the participating primary schools in Year 5, see Fig. 5.8.

Fig. 5.8: Attitudes to space module: Year 5



This was undoubtedly a very popular topic with both the boys and the girls, the mean for the cohort pupils *(n=71)* was *3.90*. The cohort girls' mean *(3.85, n=41)* was very close to that of the girls' mean *(3.81, n=52)* in the complete Year 5 and the cohort boys' mean *(3.97, n=30)* compared well with that for the boys *(3.76, n=50)* in the complete Year 5 (i.e. before attrition). Although 80% of the boys were demonstrated positive enthusiasm for the topic, it was interesting that a small percentage (10%) of the boys appeared to have very negative attitudes towards it and this may have reflected the fact that relatively little practical work was incorporated in this topic.

Sixteen girls (39% of the girls in the cohort) and 11 boys (37% of the boys in the cohort) awarded the highest scores ('5') to this topic. Data for the original 102 pupils in Year 5 – see Appendix 5.1 – supported this finding with 35% of the girls and 34% of the boys awarding the topic the highest score. There was no significant difference between the cohort Year 5 boys' and girls' means *(t=0.395, df=69, p=0.694)*.

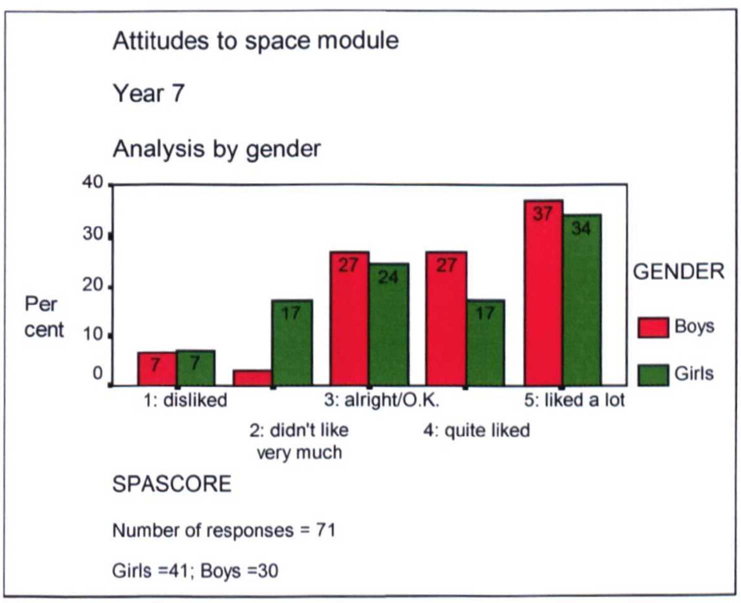
Seventy-three comments on the topic were provided by the Year 5 pupils (41 from boys, 32 from girls) of which only 9 (7 from boys, 2 from girls) demonstrated negative attitudes. A large number of the positive comments (see Appendix 5.2) focussed on the opportunity for 'learning' or 'understanding' e.g. "We learnt a lot about every planet. And learnt a ryme" (XLI19, a boy).

Many of the positive attitudes recorded by the pupils were related to the opportunity to provide artwork and to utilise their drawing skills. One of the boys, XLD19, recorded: "I enjoy talking about space & planets. Good drawing them" and a girl, XLI12, enjoyed "Using the computer for drawing planets and stars" (see also Appendix 5.2).

Another possible reason for the positive attitudes, particularly those of the girls, towards this module was an opportunity (recorded by 1 boy and 3 girls) for the pupils to demonstrate their writing skills. The gender imbalance was, however, reversed when comments underlying some of the negative attitudes to the module were examined. Three boys and one girl recorded negative attitudes which might have been attributed to the high writing content of the module. "Boring" as an explanation for poor attitude scores was given by only seven (4 boys and 3 girls) out of the 73 pupils who qualified their choice of module scores with written comments.

In Year 6, no topics on Space were undertaken but the subject was re-visited in Year 7 (see Fig. 5.9).

Fig.5.9: Attitudes to space module: Year 7

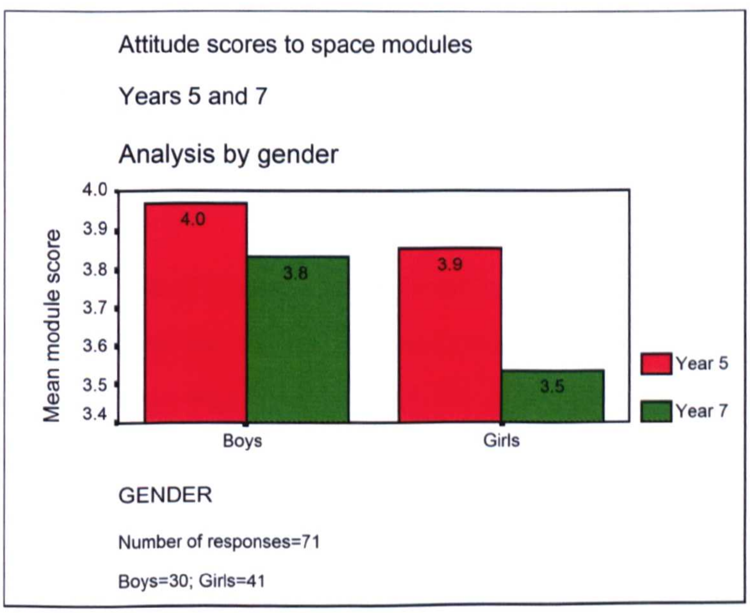


The mean score for the Year 7 cohort pupils was *3.66, SD 1.26, n=71;* there was no significant difference *(t=0.977, df=69, p=0.332)* between the boys' mean score *(3.83, n=30)* and that of the girls' *(3.54, n=41)* – see Appendix 5.1. The majority of the pupils recorded positive attitudes to the module but a small percentage (7%) of both boys and girls recorded the most negative score ('1'= disliked).

Both the boys' and girls' comments on this module were generally very positive and focussed mainly on the 'interest factor'. Apart from one girl (OLN05), whose positive attitudes were stimulated by designing mobiles of the planets, there were relatively few details which enabled an identification of the particular tasks which had generated this interest (see Appendix 5.2). Although the module revealed the highest modular mean score *(3.66)* from the pupils in Year 7, it may be that, on transfer to secondary school, this topic was rather repetitive of primary work and, compared with other work, it was less popular with the pupils. None of the comments made in Year 7 revealed any details of 'new' or 'fun' activities which had been incorporated into the module.

As no work was undertaken on Space in Year 6, the summary data for the cohort pupils presented in Fig. 5.10 is for Years 5 and 7 only. Although both the boys' and the girls' mean scores dropped between Years 5 and 7, there was no significant difference between either the boys', or the girls', mean scores during this period ($t=0.459$, $df=29$, $p=0.650$ and $t=1.332$, $df=40$, $p=0.190$ respectively).

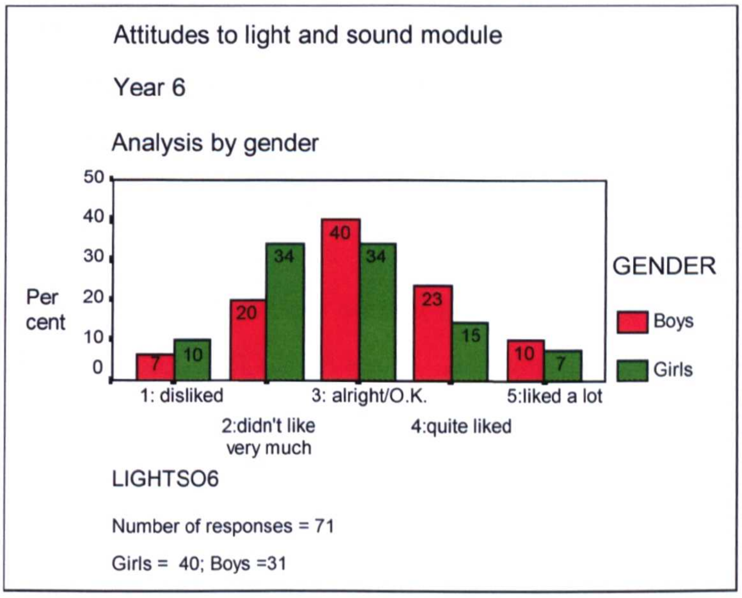
Fig.5.10: Attitudes to space modules: Years 5 and 7



5.1.4 Physical science modules: Light and sound

Light and sound were not covered by any of the primary schools in Year 5 but in Year 6 they were covered by all three schools, the distribution of attitude scores is shown in Fig. 5.11.

Fig.5.11: Attitudes to light and sound module: Year 6



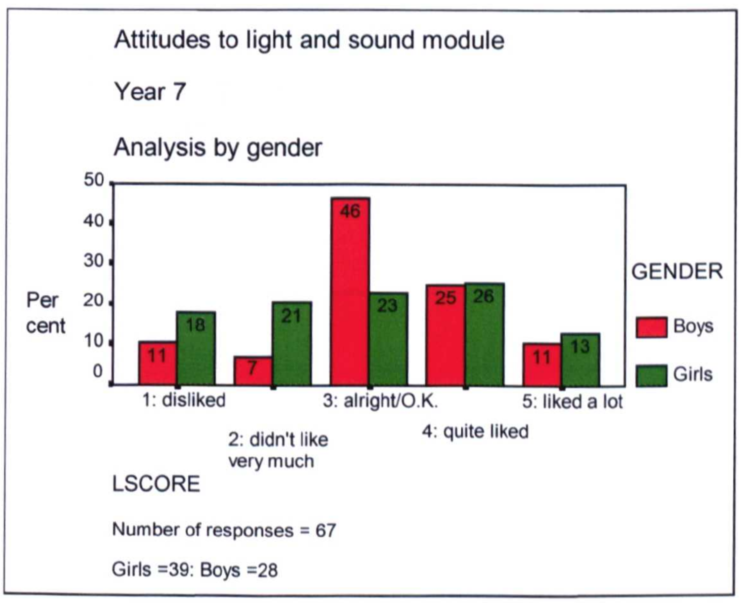
The cohort mean attitude score for the module was *2.90, SD 1.07, n=71.* Whilst the boys recorded a modal score of '3', the girls (bi-modal: 2 and 3) were rather less enthusiastic. The girls' mean score *(2.76, n=40)* was lower than that of the boys *(3.10, n=31)* the girls recording a fairly high percentage (34%) of slightly negative scores ('2'= didn't like very much). There was, however, no significant difference between the boys' and girls' mean scores *(t=1.344, df=69, p=0.183)* - see Appendix 5.1.

Relatively few pupils recorded strongly positive attitudes to this module. Ten boys (33% of the cohort boys) awarded the module positive scores compared with 9 (22%) of the girls. The gender imbalance was reversed for the negative scores ('1' and '2' taken together). This general pattern reflected that demonstrated by the pupils in the complete year group *(n=102)* before attrition in which 36% of the boys and 29% of the girls awarded positive scores to the topic (see Appendix 5.1). Negative scores were awarded to the module by 34% of the girls and 27% of the boys in the Year 6 cohort (compared with 41% of the girls and 26% of the boys in the full year group). Data for all the Year 6 pupils also suggested a greater enthusiasm for the module by the boys (*mean:3.24: modal score:3*) compared with that of the girls *(mean:2.88; modal score:2)* but, as with the data for the cohort pupils only, there was no significant difference between the means *(t=1.622, df=100, p=0.108).*

Out of 57 written comments, four referred in a positive way to 'experiments' or 'trying things out' and 6 other pupils were fairly specific about what they had enjoyed e.g."We used prisms to bounce light" (UNW09, a boy). The fact that all these positive comments came from one school (see Appendix 5.2) suggests that this school was particularly successful in stimulating interest in the module. Interestingly, two boys (UNW04 and UNW01) from the same school liked the module because "you don't have to do eny riting (any writing)" and "it was ok when we drow the pechers (drew the pictures)".

At the end of the first year at secondary school the mean score for the light and sound module (see Fig. 5.12) was *3.04, SD 1.22, n=67.* Although, as in Year 5, the boys' mean *(3.18, n=28)* was higher than that of the girls *(2.95, n=39)*, there was no significant difference between these means *(t=0.756, df=65, p=0.453)* – see Appendix 5.1.

Fig. 5.12: Attitudes to light and sound module: Year 7

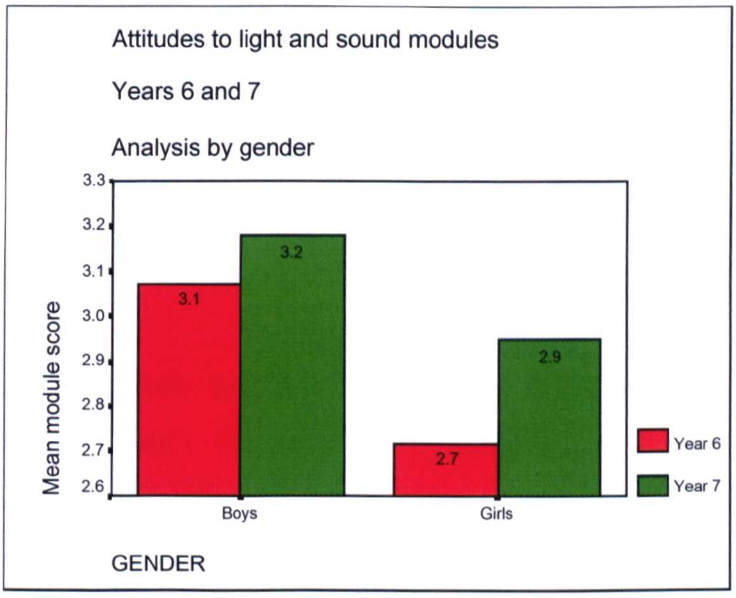


The percentage (39%) of girls who demonstrated positive attitudes (scores '4' and '5') to this module was very similar (see Fig. 5.12) to the percentage of the boys who recorded similar scores.

At the positive end of the scale, the gender difference narrowed. However the percentage of girls (39%) awarding the module negative scores was more than twice that of the boys (18%). The comments from both sexes, however, reflected attitudes at both ends of the scale e.g. "Brill" (OLU09, a girl); "boring" (XLI09, a boy) - see Appendix 5.2. One girl (UNW07) enjoyed the module because "we used coloured lights" but another girl (OLI03) thought that the experiments were "too complicated".

As no light and sound modules were covered by the pupils in Year 5, it was only possible to draw a comparison between attitude scores in Years 6 and 7, see Fig. 5.13. The negative attitudes shown by the girls in Year 6 improved slightly on transfer to Year 7 and the boys' mean score also increased very slightly. However, a paired samples *t*-test suggested that in neither case was the difference statistically significant *(girls: $t=-0.964$, $df=38$, $p=0.341$*; boys: *$t= -0.391$, $df=27$, $p=0.699$).*

Fig. 5.13: Attitudes to light and sound modules: Years 6 and 7

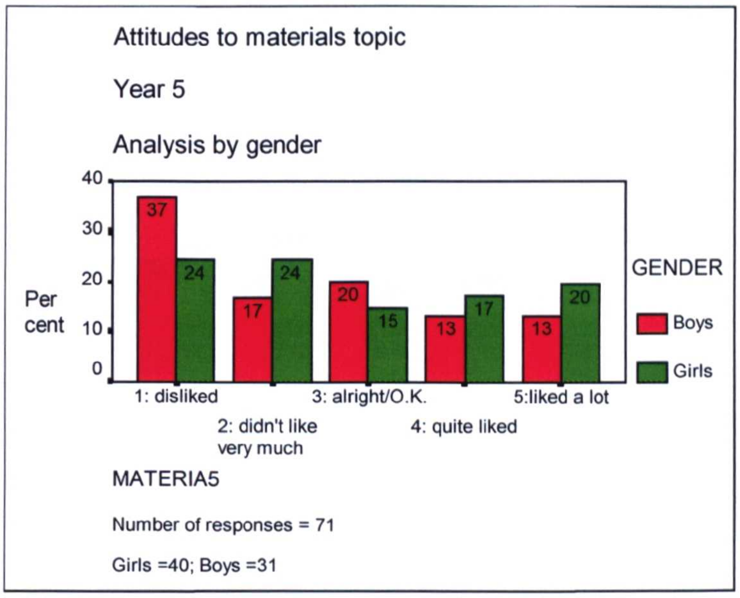


5.1.5 Physical science modules: Materials

In Year 5, the materials topic proved to be the most unpopular of all the science modules. The mean score for the cohort was *2.69, SD 1.47, n=71*; this was in close agreement with that recorded for the complete year group *(2.75, SD 1.47, n=101*). The mean of the cohort boys' scores was *2.50* (*2.72* for the complete year group) and for the cohort girls it was *2.83* (compared with *2.78* for the complete year group). In neither group, was there a statistically significant gender difference - see Appendix 5.1 - between the means (cohort: *$t=-0.932$, $df=69$, $p=0.355$*; full year group: *$t=-0.218$, $df=99$, $p=0.828$).*

As in the electricity and magnetism module, the girls demonstrated a lower percentage of very negative views (24%, compared with 37% of the boys) possibly they were more tolerant of a relatively uninspiring module - see Fig. 5.14.

Fig.5.14: Attitudes to materials topic: Year 5

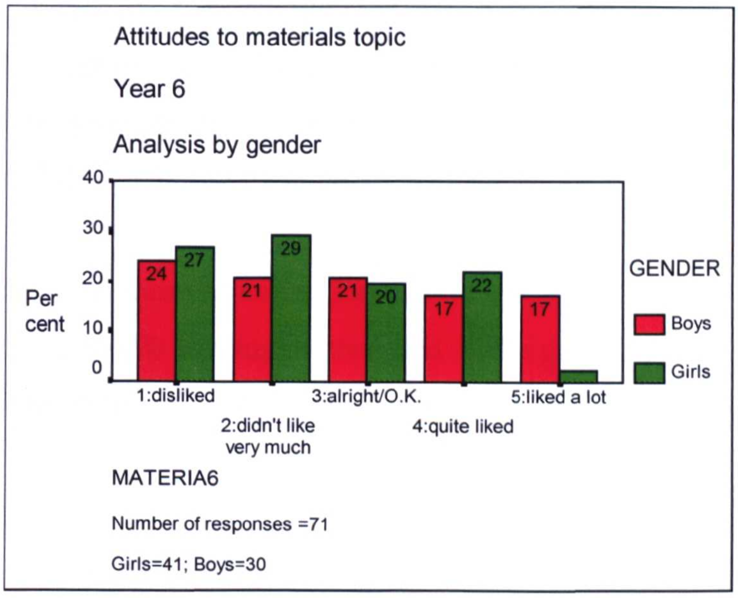


Only 23 pupils (10 boys, 13 girls) out of the 97 respondents in Year 5 (51 boys, 46 girls) gave really positive comments; several of the respondents (mainly boys) focussed on the experiments. Nine of the boys, and six of the girls, referred to experimental work in their responses e.g. "Mixing powders Fiss" (UNW16, a boy) – see Appendix 5.2.

Two pupils associated their negative attitudes to the module with a *dislike* of experimental work: "I didn't like exerments" (OLU04, girl); "We did lots of experiments which I hate" (XLD23, boy). Most of the other pupils with negative comments rarely expanded these comments beyond "boring" although a couple of boys expanded …..… "because it was mostly sorting" (OLI04); "we didn't do much about it and I wasn't very interested" (OLI05) . In four cases (3 boys, 1 girl), where negative attitudes were recorded, the "writing" content of the module was mentioned. Although a few pupils commented positively on the food experiments, one of the problems with this module seemed to be that it lacked continuity in its approach – it tended to consist of several diverse strands and, from the pupils' point of view, seemed to lack coherence. However, during interview, one of the (high ability) boys (XLI06) refuted the suggestion that the materials topic might have been better (i.e. less boring) if the work could have been spread amongst other topics.

As in Year 5, the Year 6 cohort pupils' attitudes to this topic remained very negative; the materials topic receiving the lowest of all the mean scores *(2.60, SD 1.30, n=71)* for the science topics in that year (see Fig. 5.15). This was in very close agreement with the mean score of all the Year 6 pupils before attrition *(2.68, SD 1.31, n=99)*.

Fig. 5.15: Attitudes to materials topic: Year 6



Thirteen boys (44.8%) and 23 girls (56.1%) girls awarded negative scores to the module. At the positive end of the scale, although the boys' scores were evenly distributed between the '4' and '5' scores, 9 girls (22.0% of the girls) awarded the module scores of '4' with only one girl (2.4%) recording a top score of '5'.

For the Year 6 cohort girls, the mean score *(2.44)* was lower than the boys' mean *(2.83)* but the difference was not statistically significant *(t=1.236, df=68, p=0.221)*. The pattern of responses from the cohort group was very similar to that derived from the data provided by the full year group – see Appendix 5.1.

Out of 49 comments recorded from all the Year 6 pupils *(n=99)*, there were only 6 comments (from 2 boys and 4 girls) which were fairly positive. Only two of these comments (both from girls) actually mentioned activities which the pupils specifically enjoyed: "exsment (experiment) with boiling water is good fun - how quickly it cool's" (UNW15).

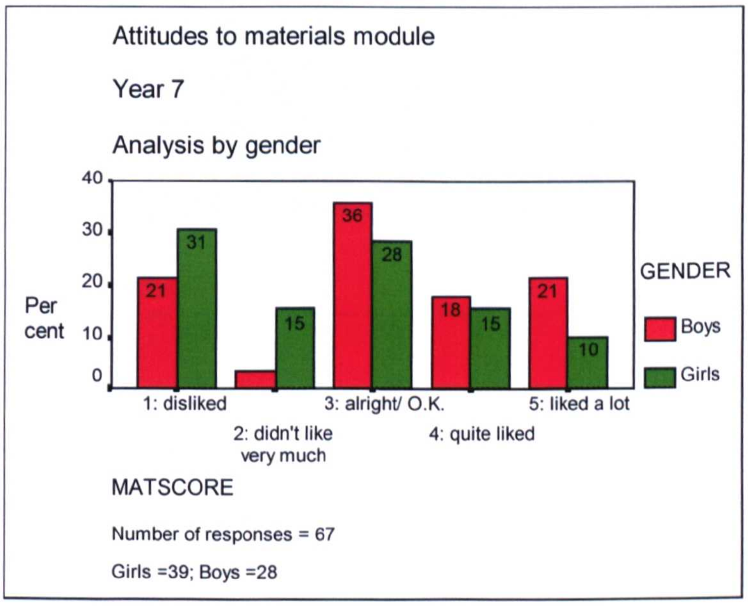
The 'mini-essay' submitted by one girl, OLN06, revealed that she was one of the very few pupils who managed to find something enjoyable in the rocks (materials) topic:

> "I only liked the bit when (we) tested rocks to see if they would crack, crumble or do nothing. We had to drop rocks down a tube and we had (to) put toilet paper at the end. When we had drop(p)ed the rocks down the tube we saw what the rocks had done".

In Year 7, the percentages of boys (21%) and girls (31%) awarding the most negative scores ('1') was higher for this module (see Fig. 5.16) than any of the other science modules covered during the year. As far as the boys were concerned, their mean module score for the materials module *(3.14)* was, however, slightly higher than that recorded for the ecosystems module *(2.93)* – see section 5.2 and Appendix 5.1.

At the end of Year 7, the mean score for the module was *2.82 (SD 1.39, n=67)*. Although the boys' mean *(3.14, n=28)* was higher than that of the girls *(2.59, n=39)*, there was no significant difference between the mean scores *(t=1.624, df=65, p=0.109)* - see Appendix 5.1.

Fig. 5.16: Attitudes to materials module: Year 7

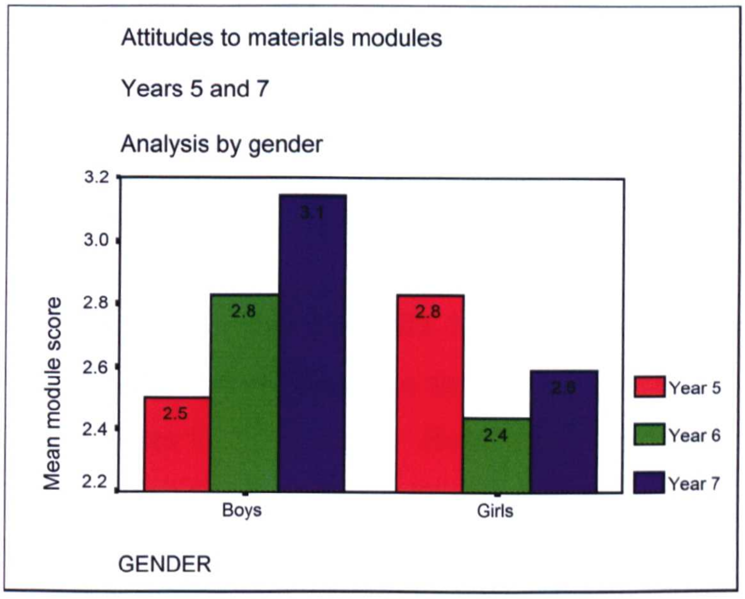


The boys' comments ranged from "excellent" (OLI12) to "boring"(UNW16). Once again, the use of the Bunsen burners attracted the interest of two of the boys (OLU11 and OLI04), both of whom recorded scores of '5' for the module. The only detailed comment (about insulation) came from one of the boys: "It was good when we was testing different types of cups" (OLU06).

The girls' comments ranged from "brill" (OLU09) to "I hated it" (OLI02) with one girl (XLI20) commenting that it was "quite hard". No boys commented on the difficulty of the module but one boy, XLD22, complained (as he had done in the other modules) that there was "too much writing".

Although, compared with other modules, the boys' attitude scores for the materials module remained low, there did seem to be some improvement over the three years (see Fig. 5.17) possibly due to the introduction, on transfer, of the Bunsen burners for practical work. The girls' scores (which had fallen dramatically in Year 6) also increased during Year 7 but the qualitative data lacked sufficient detail to suggest a possible explanation.

Fig. 5.17: Attitudes to materials modules: Years 5 and 7

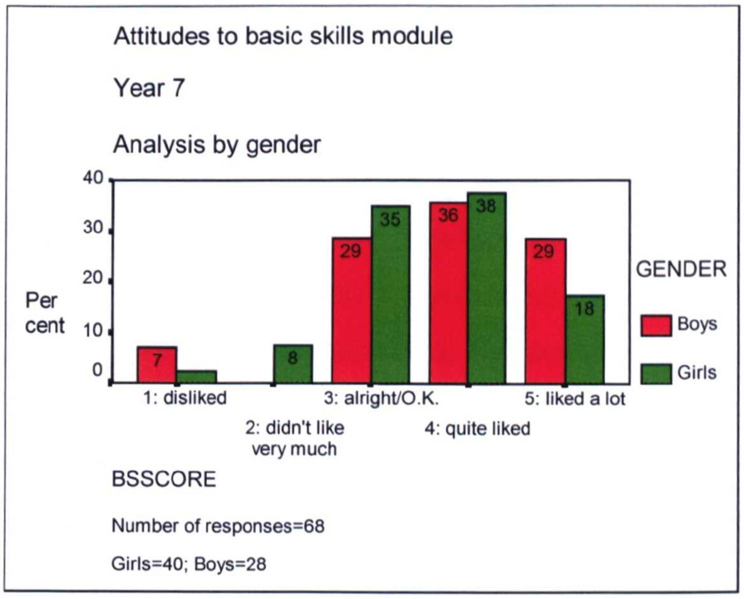


For the cohort girls *(n=41)* there was no significant difference between the mean scores in Years 5 and 6 *(t=1.456, df=40, p=0.153)* or between Years 6 and 7 *(t= -0.912, df=38, p=0.368)*. For the cohort boys there was no significant difference between the mean scores in Years 5 and 6 *(t=-0.839, df=28, p=0.409)* or between Years 6 and 7 *(t= -1.188, df=26, p=0.245)*.

5.1.6 Physical science modules: Basic skills

In Year 7, a separate 'basic skills' module was introduced which involved a variety of practical experiences in weighing and measuring, together with an introduction to the use of several items of secondary school equipment. As this type of course was devised only for the Year 7 pupils, and there were no comparable modules in any of the other years, the data from this module (Fig. 5.18) were excluded from the final calculation of the pupils' overall attitudes to science score (see Chapter 5.1). Mean attitude scores were, however, calculated (for both the boys and the girls) and the pupils' qualitative comments were also examined in detail.

Fig. 5.18: Attitudes to basic skills module: Year 7



The mean score for the cohort was *3.68, SD 1.01, n=68*; there was no significant difference *(t= 0.741, df=66, p= 0.461)* between the means of the boys' *(3.79, n=28)* and the girls' *(3.60, n=40)* scores for this module. However, this module received a greater percentage of top scores ('5') from the boys (29%) compared with the girls (18%), the main attraction for the boys seemed to be yet more opportunities to use a Bunsen burner in practical sessions e.g. "I like using Bunsen burners" (UNW29) - see Appendix 5.2.

Only one of the girls (UNW29) mentioned the use of the Bunsen burner as a reason for giving the module a top score ('5'). Repetition (of some aspects of the 'basic skills' module) was mentioned by one of the boys (OLI12) in his tape-recorded interview. Commenting on an investigation about heat loss which involved the accurate measurement of temperature and time, he volunteered: "we did that in Year 6." Another boy (XLD19) commented: "I like science but, like D. said, there is a lot of stuff that we did in year 5 and 6 like time and stuff". Two boys and three girls thought the 'basic skills' was 'easy' and the lack of difficulty seemed to be the reason for awarding positive scores to this module.

In this section the pupils' attitudes to the physical science topics have been examined; the following section (5.2) discusses the pupils' attitudes to the individual biological science topics/modules.

5.2 Attitudes towards the biological sciences

During Year 5, only two of the three primary schools (Schools OL and XL) participating in the study offered biology topics. School OL covered biological science under the single topic, 'Living things', but School XL offered the biology content as two separate, shorter topics the 'Human Body' and 'Plants'. The data obtained for each of these different topics in Year 5 therefore related to one school only and, in each case, were generated from very small samples. This created some difficulties for making a fair between-years comparison between the attitudes to the biological science topic studied in Year 5 and those studied in Year 6. It did, however, offer some opportunity for a comparison between the different approaches of the three schools. The small number of pupils studying each of the biology topics meant that it was difficult to make generalisations about the data on the biological topics in the primary years.

5.2.1 'Living things' (Year 5 - School OL only)

In Year 5, 'Living things' proved an outstandingly popular topic in School OL. The mean attitude score for the cohort[1] was *3.96, SD 1.12, n=24* (Appendix 5.1). The girls (*n=16*) demonstrated particularly positive attitudes *(mean: 4.06)* with 44% of them recording the highest score of '5' ('liked a lot'); none of them recording the most negative score ('1'). There were only 8 boys in the final cohort (i.e. after attrition) and their mean score was lower *(3.75)* than that of the girls but there was no significant difference (Mann Whitney) between the means *(Z=-0.420, p=0.697).*

In this single school, there were no significant differences between the boys' and girls' means in either the cohort pupils *(t=-0.635, df=22, p=0.532)* or the full Year 5 group *(t=-0.834, df=28, p=0.411)* – see Figs. 5.19, 5.20 and Appendix 5.1.

[1] The data from the full year group before attrition *(n=30)*, see Fig. 5.19, confirmed the positive attitudes of the girls *(n=18)* to this module *(mean: 4.17)* with 15 (50%) of them recording the highest score of '5'.

Fig. 5.19

Attitudes to 'Living things' topic

Year 5 School OL only (full year)

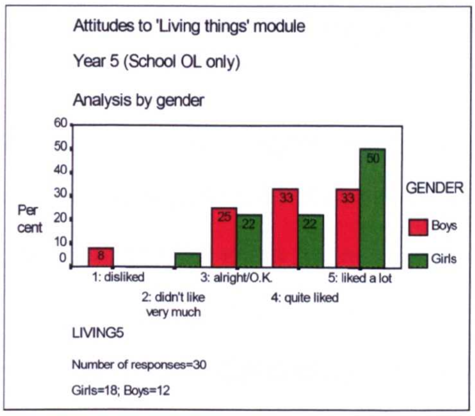
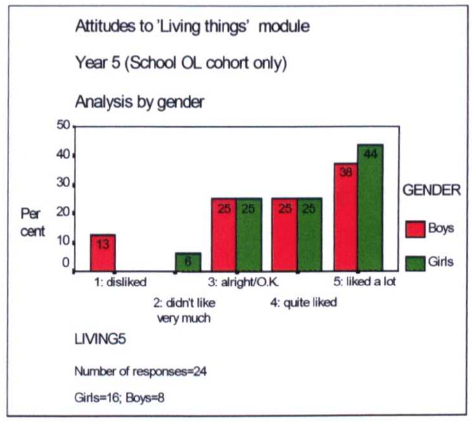


Fig.5.20

Attitudes to 'Living things' topic

Year 5 School OL only (cohort)



Examination of the responses from the whole Year 5 group at School OL showed that there were positive comments on the topic from 10 boys and 14 girls. Six of the girls (but only two of the boys) recorded positive comments which related to either the 'learning' or 'interest factor' of this topic e.g. "It is fun learning about animals and food chains" (OLI04, a boy) – see also Appendix 5.2.

An interest in the study of animals was more often cited than an interest in plant life e.g. "I like studying living things, I like animals" (OLN08, girl); "I like the human body but the plant is boring" (OLN03, boy). Only one pupil (OLU06, boy) commented on the personal relevance of studying the human body: "I find out what's inside our bodies".

There were comments (see Appendix 5.2) from five pupils who specifically mentioned drawing or artwork – four of these comments were very positive. The negative comment: "It was drawing lots of flowers which wasn't fun" (OLI12, a boy[2]) centred around his dislike of drawing flowers, animals were not mentioned – it was not clear whether it was the drawing process or the subject matter which produced his negative comments.

Of the relatively few negative comments, only one pupil, a girl, commented on perceived repetition in the curriculum: "I have done it lots of times before" (OLI04).

At School XL, the only other primary school to cover biological science in Year 5, the subject matter was divided into two separate topics: 'The human body' and 'plants'.

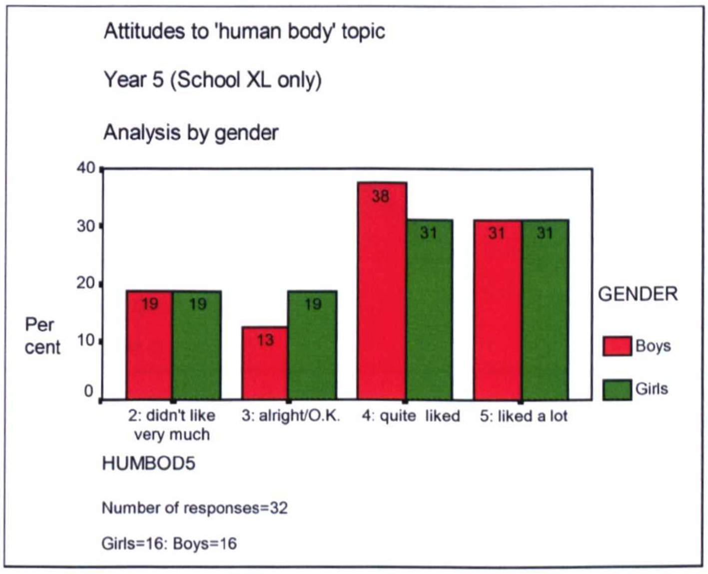
[2] awarded a neutral ('3') score to this topic.

5.2.2 'The human body' (Year 5 - School XL only)

The mean score for the study cohort[3] in this one school was *3.78, SD 1.10, n=32*; there was no significant difference (Mann Whitney: *Z= -0.157; p=0.875*) between the means of the boys' *(3.81, n=16)* and the girls' *(3.75, n=16)* scores.

Both the boys and the girls had modal scores of 4. The percentages of the boys and girls in the cohort who recorded positive scores of 4 and 5 were 69% and 62% respectively; no pupils recorded the most negative score. (see Fig. 5.21).

Fig.5.21: Attitudes to 'the human body' topic: Year 5 (School XL only)



Not surprisingly perhaps, there was a high interest factor in the human body topic and there were positive references (see Appendix 5.2) to the learning which had taken place e.g. "I learn more about myself and my body - interesting, like practical work" (XLD15, boy).

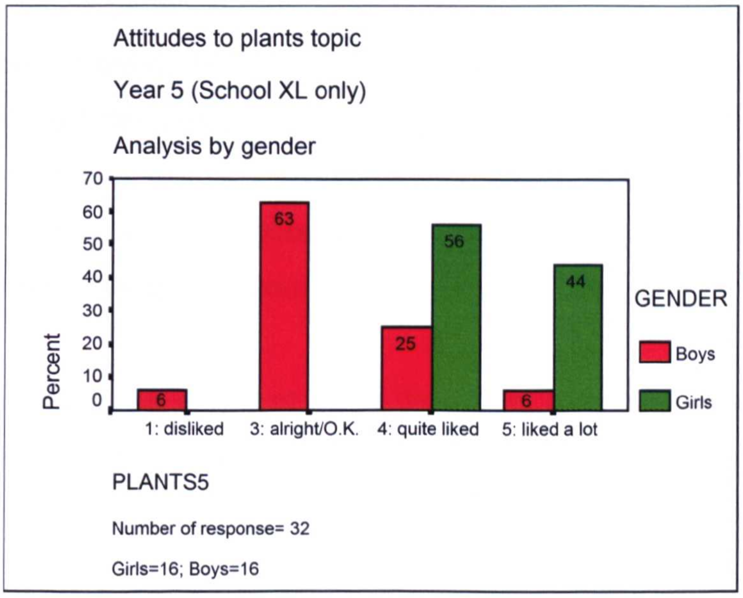
5.2.3 Plants

There was a disparity between group sizes at School XL but for the cohort pupils the mean score for the plants module was *3.84, SD 0.92, n=32*. The girls' attitudes were very positive and a significant difference *(t=-4.76, df=30, p=0.001)* was suggested between the girls' mean score *(4.44, SD 0.51, n=16)* and that of the boys' *(3.25, 0.86, n=16)*. The data for the full year group at School XL *(n=45),* and the qualitative comments, suggested that there was a significant difference between the boys' and the girls' attitudes

[3] The absence of any significant gender difference was reflected by the data from the full year group at School XL – see Appendix 5.1.

(Appendix 5.1). For the cohort pupils *(n=32), all* the girls (*n=16*) recorded positive scores[4] (i.e. none recorded scores in the '1' to '3' range) compared with only 5 (31.3%) of the boys. Ten boys (62.5%) regarded the topic as 'alright/O.K.' (score= '3') and 1 boy (6.3%) held strongly negative views (see Fig. 5.22).

Fig. 5.22: Attitudes to 'plants' topic: Year 5 (School XL only)



Although 7 of the comments (from 4 girls and 3 boys) on the plants topic used the word "interesting", reference to "planting" and "growing" appeared in 19 (of the 33) positive comments made by the pupils and these practical aspects (see Appendix 5.2) were undoubtedly major contributors to the topic's popularity e.g. "We planted a plant and we can see it grow" (XLI08, a girl). Five pupils (4 girls, 1 boy) made positive comments about the drawing although one boy disagreed: "I like the planting but I didn't like drawing" (XLI13).

5.2.4 Comparison of responses to the biology topics in Schools OL and XL

Because of the different curriculum approaches in Schools OL and XL it was not possible directly to compare the attitudes of the pupils to the biology topics in Year 5 in the two schools. However, a comparison of attitudes to biology topics in these two schools was attempted by averaging the two separate scores for the human body *('humbod5')* and plants *('plants5')* topics in School XL and comparing the derived average score

4 This agreed with the data for the complete year group at this school *(n=45)* where 19 girls (95.0%) recorded positive scores of 4 or 5 compared with only 9 (36.0%) of the boys. Although one girl in this larger sample recorded a score of '2' ('didn't like very much'), four boys (16%) seemed to hold extremely negative views about this topic.

(designated *'humplant'*) with the score for the single biology topic, living things *('living5'),* which was studied in School OL (and which covered both plant and animal biology in a single topic).

At School OL, the mean score of *4.03, SD 1.07, n=30* for the combined biology topic *('living5')* was higher than the (derived) mean score *('humplant')* at School XL *(3.67, SD 0.85, n=45)*. This lower (derived) mean score *(3.67)* was explained, at least in part, by the much lower scores awarded, particularly by the boys, to the plants topic. Whether the *higher* mean score at School OL was due to a greater bias towards human biology with less emphasis on plants, or whether other "in-school" factors (e.g. the method and style of teaching) were involved, it was not possible to ascertain, the sample sizes were very small and two different schools were involved.

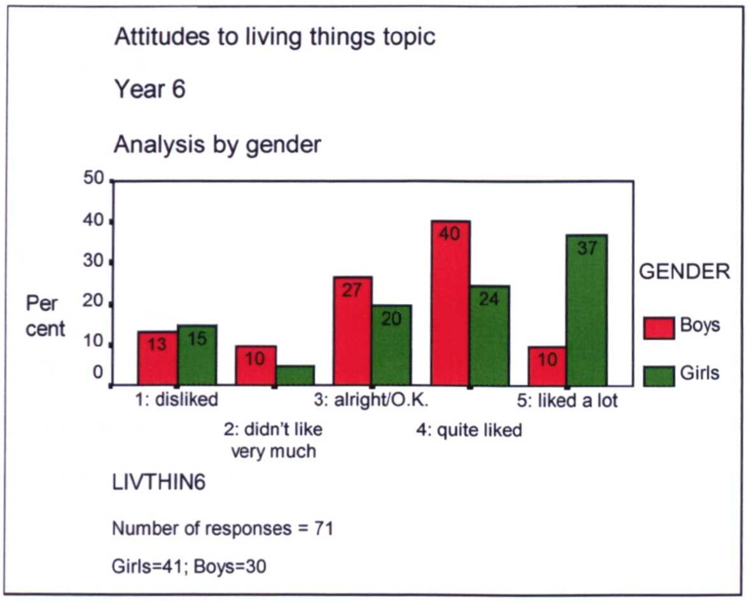
Although many of the pupils commented that the human body module was "interesting", a significant number of pupils, particularly boys, expanded their comments to include a reference to learning about how their body worked or where the different 'things' could be found.

5.2.5 'Living things' (Year 6)

During Year 6, all three primary schools studied a single biology topic 'living things' (see Fig. 5.23). For the cohort pupils, the mean score was *3.46, SD 1.33, n=71.* Although 15 (36.6%) of the girls in the study cohort[5] held strongly positive views ('liked a lot') about the module compared with only 3 (10.0%) of the boys, there was no significant difference between the boys' *(3.23, n=30)* and the girls' *(3.63, n=41)* mean scores *(t= -1.260, df=69, p=0.212).* The higher mean score of the girls was supported by the data for the full year group *(n=102).*

[5] This gender bias was supported by the data from the full Year 6 cohort before attrition; 40.4% of the girls, compared with 12.0% of the boys, recorded strongly positive scores for this module.

Fig. 5.23: Attitudes to 'living things' topic: Year 6



Interest in human biology had been stimulated at two of the schools by a visit to the local teaching hospital where the brain had obviously been the subject of discussion One girl (UNW01) commented: "We went up to the (hospital) for a brain test".

The majority of the 53 comments on the returned questionnaires were positive and referred to the various aspects of human biology which had been of interest; plant biology attracted fewer positive comments. Several pupils commented in their 'mini-essays' that ease of understanding together with a high interest factor were necessary ingredients for a topic to be classed as a 'favourite':

> "I liked this because I could understand it and it was interesting…we learnt how the body works and were everything is."
>
> (OLN04, a girl)

"Interesting" and/or "fun" were frequently used words but the pupils recorded relatively little detail about the specific source of the interest. "Boring" only appeared three times amidst the comments although a fourth pupil, OLN07 (a girl) gave the module the lowest score of '1' "because some of the things we learnt we already knew".

There were no comments from the Year 6 respondents about the drawing/artwork involved in the 'Living things' module. This contrasts with the responses (from the pupils in School OL) at the end of Year 5 in which 4 of the 5 comments suggested that the positive attitudes were based, at least in part, on the drawing component of the module.

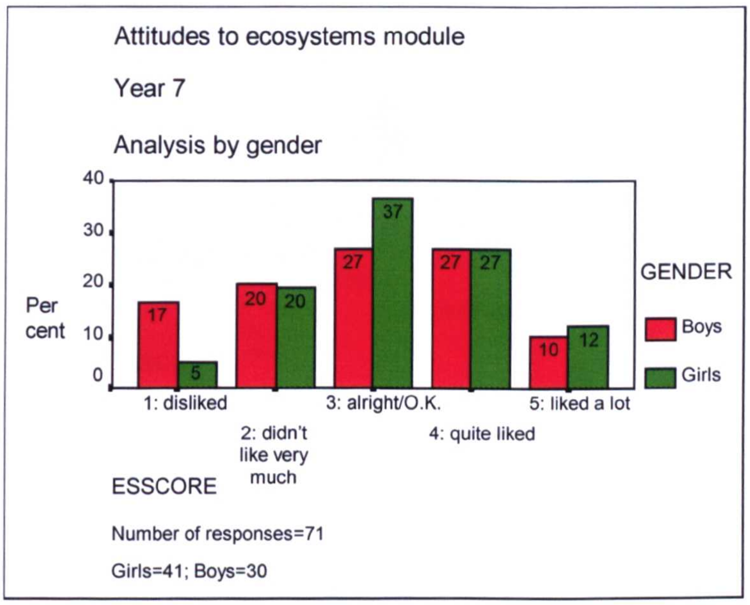
Negative comments in the 'mini-essay' occasionally focussed on the need, as in the plants topic, for factual learning:

> "I did not enjoy the plants because you had to remember parts of the plants."
>
> **(OLN10, a boy)**

5.2.6 Ecosystems

In Year 7 the biological sciences were spread between two modules, ecosystems and processes of life. The ecosystems mean score for the cohort was *3.10, SD 1.15, n=71* (see Fig. 5.24). There was no significant difference *(t=-1.038, df=69, p=0.303)* between the boys' mean score (*2.93, n=30*) and that of the girls' (*3.22, n=41*).

Fig.5.24: Attitudes to ecosystems module: Year 7



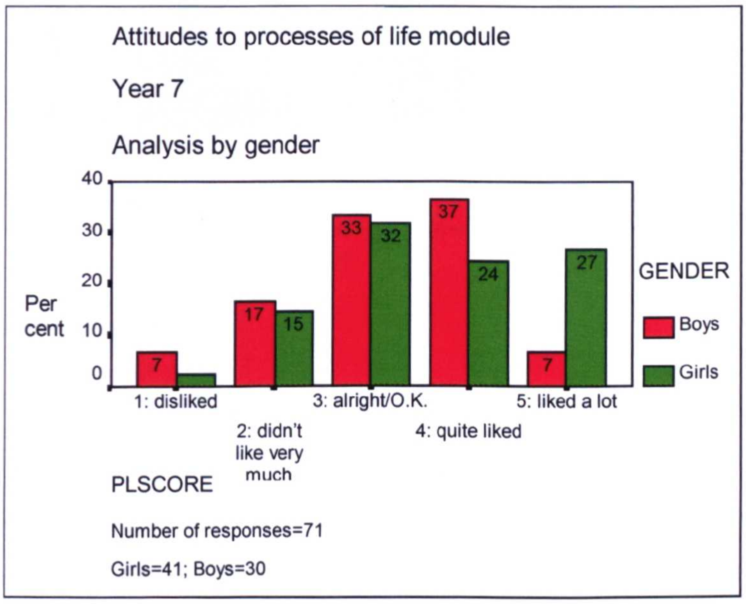
Although, at the upper end of the scale, the percentage of boys (36.7%) awarding the module positive scores of '4' or '5' was almost identical to that of the girls'(39.0%), five of the boys (16.7%) recorded the most negative scores (disliked ='1') for this module. Comments from six of the boys included the absence of practical work (XLD19, XLI09), the lack of experimental work together with the degree of difficulty (XLD23) and "too much writing" (XLD22). One boy (UNW16) "found it hard" and another (OLU06) commented: "…I don't like drawing things like nature and we didn't do practicals."

Only 2 girls (4.9%) recorded the lowest score for this module and, although none of the girls was critical of the apparent lack of practical work, the girls' comments were generally similar to those of the boys. Two of the girls mentioned that there was "a lot of drawing" (XLD06) and "too many diagrams" (OLI03) and two others (OLN07 and XLI15) commented on the degree of difficulty. There were, however, a couple of more positive comments: "Brilliant" (XLD02), "I enjoyed ecosystems because I adore animals" (UNW07).

5.2.7 Processes of life

For the processes of life module (see Fig. 5.25), the mean score for the cohort was *3.42, SD 1.09, n=71*. There was no significant difference *(t=-1.483, df=69, p=0.143)* between the boys' mean score *(3.20, n=30)* and that of the girls' *(3.59, n=41)*.

Fig.5.25: Attitudes to processes of life module: Year 7



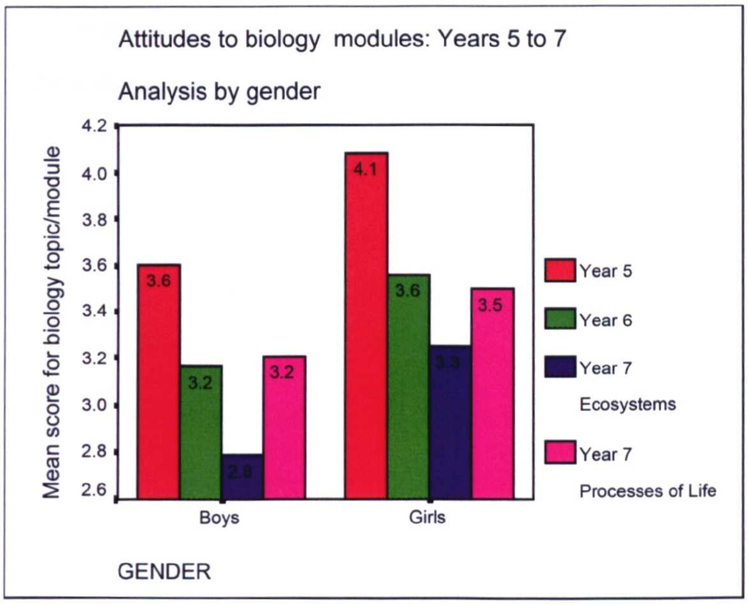
The girls' attitudes were particularly positive - 11 girls (26.8%), but only 2 boys (6.7%), recorded scores at the top end of the scale ('5'). The boys' comments on this module ranged from "good fun" (OLI12) to "boring" (XLI09) but revealed relatively little information about the influences on the pupils' attitude formation. The girls' comments were also wide-ranging and relatively uninformative, from "really good – interesting" (UNW17) to "not much fun" (OLU12). Two girls commented on the apparent repetition e.g. "It was the same as in primary school" (OLN11).

The attitudinal data for the 'living things' topic in Year 6, together with data for the two separate modules (Ecosystems and Processes of Life) studied in Year 7, is presented in Fig. 5.26. (Only two of the three primary schools, OL and XL, studied biology in Year 5 but the cohort data from these two schools[6] are also included for comparison). In Year 8

[6] Based on data from cohort pupils in Schools OL *(n=24)* and XL *(n=32)*; for Years 6 and 7, *n=71.*

attitudinal data were not sought on *individual*[7] biology modules; instead pupils' scores for the biological sciences modules as a whole were recorded.

Fig. 5.26: Attitudes to biology modules: Years 5 to 7



5.2.8 Year by year comparisons

Quantitative and qualitative data were available for the pupils' attitudes to the biological science modules in Years 5 to 8. However, there was a lack of uniformity, particularly in the primary phase, in the content of the biological science topics and this presented difficulty, because of the small numbers of pupils studying some of the topics, in drawing year by year comparisons.

For the boys', no significant difference was suggested between their mean attitude scores to the 'plants' module between Years 5 and 6 *(t=0.447, df=7, p=0.668)* or to the Ecosystems module between Years 6 and 7 *(t=0.902, df=29, p=0.375)*. The Year 7 boys' mean attitude score *(3.20)* for the 'Processes of life' module showed virtually no change from that of the 'Living things' module in Year 6 *(3.23)*. For the girls, however, a significant difference[8] was suggested between the attitude scores for biology topics in Years 5 and 6 *(t=2.959, df=15, p=0.010)*.

[7] see Chapter 5.3.4.
[8] based on limited data from 16 pupils who studied biology ('Living things') in Year 5.

Comparisons of attitudinal data relating to the final cohort *(n=71)* with those derived from the original, larger group of Year 5 and 6 pupils *(n=102)* suggested that the final cohort was generally representative of the larger group of pupils before attrition. The quantitative responses to these individual modules were used as the basis for calculating the cohort pupils' mean scores for the physical and biological sciences; these are discussed in the following section (5.3).

5.3 Comparison of physical science and biological science scores

One of the main research objectives of this study was to examine the change, if any, in pupils' attitudes to the biological and the physical sciences over a 4-year period (see 5.1 and 5.2). In order to achieve the fair comparisons necessary for this objective, only the data for those 71 pupils who completed all four annual questionnaires were used in the following comparative analyses but some data relating to the larger group of pupils *(n=102),* together with some data for separate schools, are also included in Appendix 5.3.

In order to obtain the mean attitude scores in Years 5 to 7 for the biological and physical sciences, the individual science modules studied each year were assigned to one of two mutually exclusive groups, 'biological science' or 'physical science' and the mean attitude scores for the modules in each of these two groups were then calculated.

5.3.1 Year 5

In Year 5, the electricity & magnetism and forces modules were covered by only one school (UN) and only 15 pupils from this school completed all four annual questionnaires and were therefore included in the final cohort. All three primary schools completed topics on space and materials but the physical sciences data available for the Year 5 pupils lacked consistency.

Using the limited data provided for the four topics by the pupils *(n=15)* at School UN, the alpha reliability score for the physical sciences in Year 5 was *0.5620.* Reliability analysis showed that, for the physical science scores, alpha was increased in Years 5 and 6[1] by removing the scores for the 'materials' topics (see 5.1). The foci of these 'materials' topics varied from school to school and the content was not necessarily orientated towards the physical sciences. For Years 5 and 6, therefore, *adjusted* mean scores for the physical sciences (i.e. excluding the 'materials' topic scores) were used for the comparative analyses with the biological sciences. In Year 7, the reliability analysis gave a score of *0.7642* and this suggested that the pupils' attitudes to the 'materials' module were not now significantly different from those towards the other modules.

In Year 5, no biological science topic was conducted in School UN and so it was only possible to compare the cohort mean attitude scores for the physical sciences *(3.80)* and the biological sciences *(3.85)* in two of the schools, OL and XL. There was no significant

[1] from *0.5620* to *0.6404* (Year 5) and from *0.7145* to *0.7332* (Year 6).

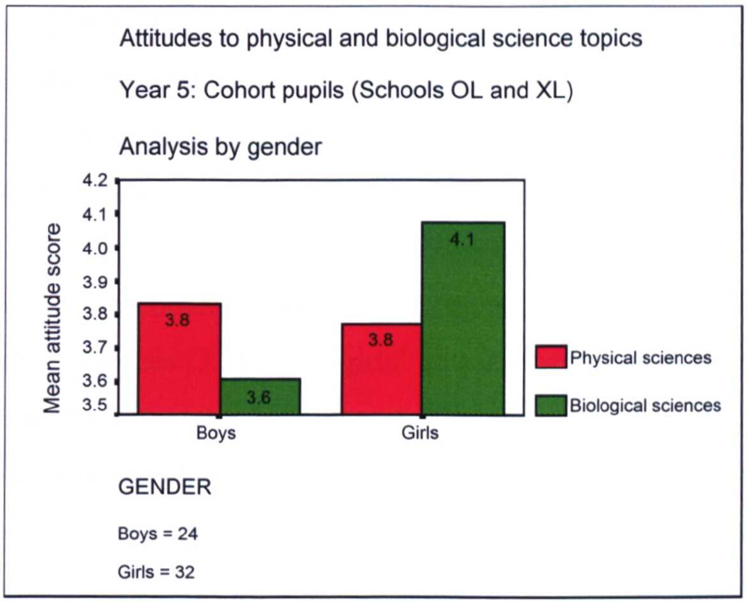
difference between the means (Appendix 5.3). The means for the full year group *(n=75)* in these two schools were identical *(3.81)* and the data suggested that there was good agreement, for pupils at these two schools, between the attitude scores of the pupils in the original Year 5 group at these two schools and those of the pupils who remained in the study cohort. A comparison of mean attitude scores for the biological and physical sciences showed that the data for these two groups were in close agreement – see Table 5.2.

Table 5.2:Distribution of means for the physical and biological sciences Years 5: Schools OL and XL only (full year and final cohort pupils)

Group	Higher mean scores					
	Physical sciences		Biological sciences		No difference	
	n	%	*n*	%	*n*	%
Year 5						
Pupils from Schools OL and XL *(n=75)*	14	18.7	28	62.6	14	18.7
Pupils from Schools OL and XL in the **Final cohort** *(n=56)*	9	16.1	37	66.1	10	17.8

Data for the cohort pupils at Schools OL and XL showed (Appendix 5.3) that the Year 5 girls' (*n=32*) mean attitude score for the biological sciences *(4.08)* was significantly different *(t= -2.013, df=54, p=0.049)* from that of the boys *(3.60)* and this gender bias in Year 5 was reflected by the data derived from the full year group in these two schools (see Fig. 5.27).

<u>*Fig. 5.27: Attitudes to physical science and biological science topics*</u>
<u>*Year 5: Schools OL and XL (cohort pupils)*</u>



The cohort boys' mean attitude score for the physical sciences *(3.83)* was higher than that for the biological sciences *(3.60)* but the preference was reversed for the girls (*3.77* for the physical sciences and *4.08* for the biological sciences). In neither case was the difference statistically significant.

5.3.2 Year 6

During Year 6, all the three primary schools covered the same four science topics and so comparisons between the mean attitude scores for the biological science ('Living things') and physical science topics for the final study cohort *(n=71)* could be made. In Year 6, the cohort pupils *(n=71)* in all three primary schools studied magnetism & electricity, light & sound and materials. The alpha reliability score for these three physical science modules was *0.7145*. Removal of the materials component from the analysis meant that, for the remaining two modules (light & sound and magnetism & electricity) the *adjusted* mean physical sciences score was *3.11 (alpha = 0.7332)*. Only one biology topic, 'Living things' was studied during Year 6 in the three participating primary schools.

For the study cohort *(n=71)*, there was a significant difference *(t=-2.095, df=70, p=0.040)* between the mean attitude scores for the biological *(3.46)* and physical *(3.11)* sciences. (Data for the complete year group of 102 pupils, before attrition, are also given in Appendix 5.3 together with data from Schools OL and XL[2] taken together for comparison with Year 5).

For the 71 cohort pupils, 45 pupils (63.3%) had higher mean scores for the biological sciences than for the physical sciences but only 20 pupils (28.2%) had higher mean scores, relative to the biological sciences, for the physical sciences. Six pupils (8.5%) had no difference between their recorded mean scores for the two categories (Appendix 5.4).

As in Year 5, the boys recorded a lower[3] mean score for the biological sciences *(3.23)* than for the physical sciences *(3.38)*. The girls' attitudes were considerably more positive to the biological sciences *(mean: 3.63)* than to the physical sciences *(mean: 2.90)* and there was a statistically significant difference between the two means *($t=-2.857$, $df=40$, $p=0.007$)*. For the physical sciences, there was a significant difference between the means of the boys' *(3.38)* and the girls' *(2.90)* scores *($t=2.121$, $df=69$, $p=0.038$)*.

5.3.3 Year 7

In Year 7, the attitude scores for all the science modules (except basic skills) were assigned either to the biological sciences or to the physical sciences categories. By the end of Year 7, the inter-school variations had been eliminated and the pupils had all covered the same science modules. These modules, apart from the basic skills module (see 5.1), were assigned to either the physical sciences or the biological sciences category; the attitude score for the biological sciences was taken as the average of the scores for the 'Ecosystems' and the 'Processes of Life' modules.

In the physical sciences the modules covered were: electricity and magnetism, light and sound, forces, space and materials. For the full cohort *($n=71$)* the alpha reliability score for these modules was *0.7642* and the mean attitude score for the physical sciences was *3.23*[4].

For the girls in the cohort *($n=41$)*, a paired samples *t*-test showed that there was a significant difference *($t=2.313$, $df=40$, $p=0.026$)* between the mean attitude score for the biological sciences *(3.40)* and that for the physical sciences *(3.03)* – see Appendix 5.3.

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[2] In Year 5, only Schools OL and XL studied biology topics

[3] not statistically significant

[4] obtained by averaging the five modular scores for Space; Electricity and Magnetism; Forces and Energy; Light and Sound; and Materials.

As in the previous two years, the boys' mean score for the physical sciences *(3.51)* was higher than that for the biological sciences *(3.06)* and, by Year 7, there was a statistically significant difference in the two scores *(t=-3.134, df=29, p=0.004).*

The percentage of cohort pupils preferring the physical sciences had risen from 28.2% in Year 6 to 39.4% in Year 7 and the number preferring the biological sciences had been reduced from 63.3% to 47.9% – see Appendix 5.4. Nine pupils in Year 7 had identical mean scores for both types of module compared with 6 pupils (who showed no difference between their physical and biological mean scores) in Year 6.

For the physical sciences, an independent samples *t*-test showed that the difference in gender means *(boys: 3.51; girls: 3.03)* was significant *(t= 2.384, df= 69, p=0.020)* and there appeared to be a clear preference by the boys for the physical sciences. Almost all of the positive comments made by the boys referred to the practical work: "we did lots of experiments" (OLI04), "lots of experiments interesting" (OLI12) and "there is a lot of practical in this" (UNW09). Despite the difference in the distribution of the girls' scores compared with the boys, the girls' comments frequently included references to the fact that there were "good practicals" (OLN04), "a lot of practicals" (UNW29) or "the experiments were cool" (UNW15).

5.3.4 Year 8

By the end of Year 7, the detailed data provided by the pupils on the individual modules had provided little new information and so it was decided to sacrifice some of the specific questions about these individual modules in Year 8 and, in line with the research objectives, to concentrate on the pupils' attitudes towards the three sciences (biology, chemistry and physics) which make up the biological and physical sciences. By Year 8, each class was often taught by more than one teacher who would possibly be teaching modules outside his/her own main specialism.

The Year 8 data therefore allowed an examination to be made of the gender differences in pupils' attitudes to the biological sciences and the physical sciences (see Chapter 3), particularly their attitudes towards the separate specialisms of biology, chemistry and physics. The mean physical science score for each pupil was derived by averaging the six scores for the physics and chemistry modules; the biological science score was taken as the mean score over all three biology modules.

Although, in Year 8, the cohort appeared to demonstrate an overall preference towards the physical science modules, there was no significant difference between the cohort *(n=70)* mean score for the physical sciences *(3.41)* and that for the biological sciences *(3.10)*. Twenty-three pupils (32.9%) had higher mean scores for the biological sciences than for the physical sciences but 38 pupils (54.4%) had higher mean scores for the physical sciences. Nine pupils (12.7%) showed no difference between their recorded mean scores for the two categories.

For the girls in the cohort (*n=41*), there was a no significant difference *(t=1.569, df=40, p=0.125)* between the mean attitude scores for the biological sciences *(3.29)* and that for the physical sciences *(2.95)*; in Year 7 a significant difference *(p<0.05)* had been suggested. For the boys, however, there was (as in Year 7) a significant difference *(t=-5.037, df=28, p=0.001)* between the mean attitude scores in favour of the physical sciences *(mean scores: 2.80* and *4.07* for the biological and physical sciences respectively). Full details of the scores are given in Appendix 5.3.

For the physical sciences, the difference in mean scores *(boys: 4.07; girls: 2.95)* was highly significant *(t= 5.157, df= 68, p=0.001)*, there had also been a significant difference between the means in Year 7 *(t=2.384, df=69, p=0.020)*.

For the Year 8 boys, there was a significant increase (from *3.51* in Year 7 to *4.07* in Year 8) in their mean attitude score towards the physical sciences *(t=3.122, df=28, p=0.004)* and the difference *(1.27)* between the mean biological science and physical science scores for the boys in Year 8 widened compared with that *(0.45)* recorded in the previous year - see Appendix 5.3. It appeared that, whilst the boys were developing more positive attitudes to the physical sciences, their attitudes to the biological sciences were also deteriorating[5].

5.3.5 Cohort and non-cohort pupils

Comparison of the non-cohort pupils' data with those of the final cohort suggested that, in Year 6, there was no significant difference between the attitudes of the non-cohort, and the cohort, pupils towards either the biological *(t=-0.872, df=100, p=0.385)* or the physical sciences *(t=-1.586, df=100, p=0.116)*. The mean biological science and physical science scores for the study cohort, analysed by gender, are shown in Fig. 5.28 and Fig. 5.29.

[5] no statistically significant difference *(t=1.295, df=29, p=0.205)* between the mean biological sciences score of *3.06* (Year 7) and *2.80* (Year 8).

Fig. 5.28: Mean biological science scores: Years 5 to 8

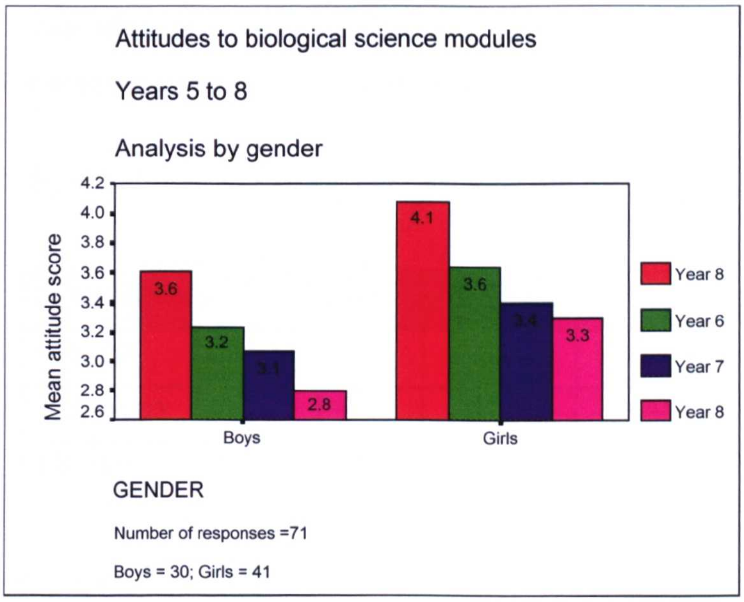
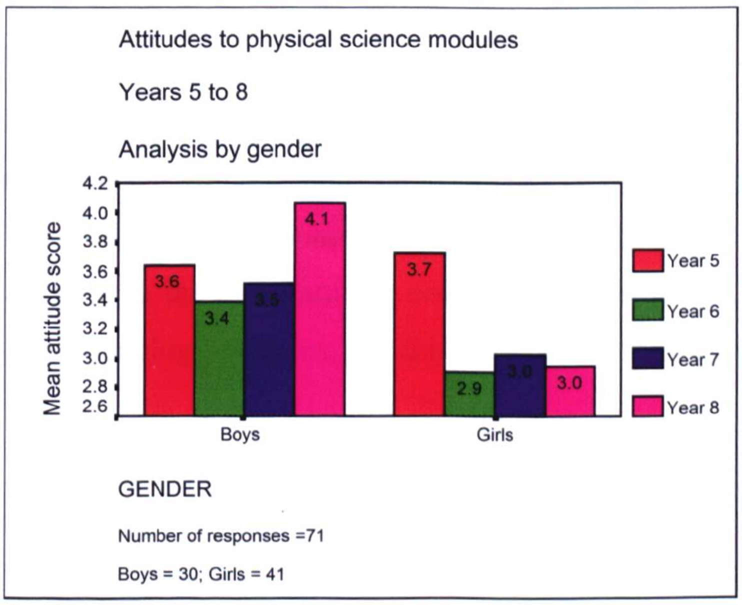


Fig. 5.29: Mean physical science scores: Years 5 to 8



5.3.6 Attitudes to biology, chemistry and physics modules in Year 8

Having investigated the pupils' attitudes to the biological and physical sciences, the cohort pupils' mean attitude scores for the three groups of modules (i.e. biology, chemistry and physics) were examined separately, see Table 5.3.

Table 5.3: Mean attitude scores for biology, chemistry and physics modules: Year 8

Specialism	*Mean*	*SD*	*n*
Biology	3.08	1.17	71
Chemistry	3.49	1.15	70
Physics	3.37	1.33	70

Overall, the cohort pupils demonstrated slightly more positive attitudes to the chemistry modules compared with the physics modules; the biology modules were the least popular. The distributions of the cohort pupils' scores to the three sciences, analysed by gender, are given in Appendix 5.5.

The Year 8 cohort pupils' mean attitude scores towards the three sciences, as well as those of a randomly selected group of non-cohort pupils (16 boys, 19 girls) are given in Appendix 5.6. The data for the non-cohort pupils suggested that there were significant gender differences between the mean attitude scores for the chemistry, and the physics modules, but not for the biology modules; and this is in agreement with that found for the cohort pupils.

5.3.6 (i) Attitudes towards biology modules

The cohort *(n=71)* mean score for the biology modules was *3.08, SD 1.17.* The boys' mean attitude score *(2.80)* was lower than that of the girls *(3.29)* but no significant difference between the boys' *(n=30)* and the girls' *(n=41)* mean attitude scores was suggested for the biology modules – see Appendix 5.6. Compared with the boys, the girls recorded a higher percentage (46.3%) of positive (i.e. '4' and '5') scores than the boys (28.9%) for the biology modules. The modal score for the girls was '4', for the boys it was '3'.

Examination of the qualitative comments revealed that, in line with the comments made in Year 7, the boys generally lacked enthusiasm for the biological sciences. Ecosystems, again, was cited as "boring" by one boy (OLI05) although one girl (OLI10) specifically mentioned ecosystems as "enjoyable and interesting". Another boy (XLD23) linked his statement that the biology modules were "boring" with a comment that they were a "bit difficult to understand". The perceived difficulty of the biological sciences attracted comment from two of the girls (OLI03 and OLI08); one girl (OLU07), however, commented that the biology modules were "easy to understand".

Although the girls produced several negative comments e.g. "it was not that interesting it was borring" (XLD07) and "I get bored after a while, because there's not much to learn" (OLN06), there were also plenty of comments which suggested positive attitudes towards the biological sciences: "its fun" (XLI11 and UNW29); "its good fun" (OLN04), "really good" (XLD04) and "its O.K." (OLI02, XLD06 and XLI04). One girl (OLN05) commented: "I get bored when you keep drawing cycles" (presumably referring to the ecosystems module); another girl (UNW07) commented: "I don't like blood but I don't mind life cycles".

Two boys (OLI12 and UNW09) and two girls (XLD05 and OLN07) commented on the absence of practical work in the biological science modules but two of the pupils (UNW09 and XLD05) both awarded positive scores ('4') for the biology modules as a whole.

5.3.6. (ii) Attitudes towards chemistry modules

The cohort mean score for the chemistry modules was *3.49, SD 1.15, n=70.* The modal score for the boys was '5'; for the girls it was only '3'. There was a significant difference *(t=2.615, df=68 p=0.011)* between the boys' mean score *(3.90)* and that of the girls *(3.20)* – see Appendix 5.6.

As in Year 7, almost all of the positive comments made by the boys referred to the practical work: "we did lots of experiments" (OLI04), "lots of experiments interesting" (OLI12) and "there is a lot of practical in this" (UNW09). Despite the difference in the distribution of the girls' scores compared with the boys, the girls' comments frequently included references to the fact that there were "good practicals" (OLN04), "a lot of practicals" (UNW29) or "the experiments were cool" (UNW15).

5.3.6 (iii) Attitudes towards physics modules

The cohort mean score for the physics modules was *3.37, SD 1.33, n=70*. The modal score for the boys was '5'; for the girls it was only '2'. There was a highly significant difference *(t=5.479, df=68, p= 0.001)* between the boys' mean score *(4.24)* and that of the girls *(2.76)* for these modules.

This highly significant gender difference in the mean attitude scores for the physics modules was supported by the qualitative comments, the boys commenting positively on the practical aspects: "loads of practical" (XLD16), "there is a lot of practical" (UNW09) and, more specifically: "you put switch boards together" (XLD12). One boy, XLD23, commented: "Its very practical in real life (wiring plugs etc. comes in handy in life), easier to understand". Only a couple of girls gave strongly positive comments: "I love physics, very interesting and easy to understand" (OLI02), "great" (XLD05), "you get to do lots of experiments and draw lots of pictures" (OLN06). The majority of the girls' comments were rather negative and ranged from "uninteresting" (OLI10) and "it sometimes gets boring" (OLN04) to "the dullest thing on the planet!!" (OLN01). Two girls linked their boredom to repetition: "it was very boring as we did it in yr 6 and 7" (OLN11) and " I didn't like this because we do it every year and it's boring. It's hard to understand" (OLN07).

5.3.7 Years 5 to 8: comparisons

Data on Year 5 pupils' attitudes to biology topics were available from only two schools but a comparison of data from the 56 cohort pupils at the two schools (OL and XL) which did cover biological science in Year 5, with that from the same pupils in Year 6, suggested that the boys' lower enthusiasm for the biological sciences (compared with the physical sciences) which was apparent in Year 5 was less pronounced in Year 6 and the gap narrowed slightly (see Appendix 5.6). However, for the cohort girls from these two schools, the already significant difference between their physical science and biological science scores (in favour of the biological sciences) in Year 5 widened further in Year 6. This may suggest that, as the girls become increasingly aware of the content of 'science', the polarisation of their preferences towards biological sciences also increases; there were fewer "neither like it nor dislike it" scores.

The cohort boys seemed to find little new to interest them in the physical sciences in Year 6 (see section 5.1); there was no significant change in the *adjusted* mean attitude score for the physical sciences between Years 5 and 6 *(t=0.911, df=28, p=0.370)*. However, the subsequent improvement of attitudes on transfer to Year 7, although not statistically significant *(t=-0.804, df=29, p=0.428)*, increased significantly *(t=-3.122, df=28, p=0.004)* by the end of Year 8 (where it exceeded the Year 5 level).

For the 24 cohort boys who had studied biology in both years (i.e. from primary schools OL and XL) there was no significant difference *(t=1.785, df=23, p=0.087)* between the mean attitude scores to the biological science topics in Years 5 and 6. For the full cohort of boys *(n=30)*, the differences between the mean scores to biological science modules in Year 6 *(3.23)* and Year 7 *(3.06)* and between Year 7 *(3.07)* and Year 8 *(2.80)* were also not significant *(t=0.583, df=29, p=0.585* and *t=1.295, df=29, p=0.205* respectively).

For the girls *(n=41)*, there was a highly significant difference in the mean attitude score for the physical sciences between Years 5 and 6 *(t=3.567, df=40, p=0.001)*. This significant dip in enthusiasm for the physical sciences in Year 6 improved slightly on transfer *(t=-0.762, df=40, p=0.451)* but fell very slightly (from *3.03* to *2.95*), by the end of Year 8 *(t=0.505, df=40, p=0.616)*.

Despite the preference shown by the girls for the biological sciences, compared with the physical sciences, their mean attitude scores to biology decreased between Years 5 and 8. Comparisons could only be made between Years 5 and 6 for the girls *(n=32)* who had studied biology in both years. There was no significant difference *(t=1.830, df=31, p=0.077)* between the mean attitude scores to biology in Years 5 and 6. For the full cohort of girls *(n=41)*, the differences between the mean scores in Years 6 and 7 and between Years 7 and 8 were also not significant *(t=1.050, df=40, p=0.300* and *t=0.566, df=40, p=0.575* respectively*)*.

These data on the mean attitude scores to the biological sciences, together with those on the physical sciences (5.1) enabled a mean attitude to science score (over all modules) to be derived – these are presented in the following section (5.4).

5.4 Attitude to science scores (over all modules)

Following a detailed analysis of the pupils' physical, and biological, sciences scores (see 5.1 and 5.2), for each year of the study, the mean science score for each pupil was calculated by averaging the attitude scores for each of the science-based topics/modules[1] studied during that year - see Appendix 5.1. In order to establish an overall pattern for the science modules as a whole these scores were then analysed by gender and examined for annual trends.

5.4.1 Analysis by gender

The gender differences between the mean science scores were not significant in any of the years except Year 8 when a significant difference was detected *(t=2.733, df=69, p=0.008)* between the boys' and girls' mean science scores (*3.59* and *3.06* respectively) – see Appendix 5.7. This gender difference was explained by the widening gap between the boys' and girls' attitudes to the physical sciences. The boys' lessening enthusiasm for the biological sciences was not, however, as significant as the girls' increasingly negative attitudes towards the physical sciences (see section 5.3).

5.4.2 Year by year comparisons

5.4.2.(i) <u>*Girls' scores*</u>

A paired samples *t*-test showed a highly significant difference *(t=4.434, df=40, p=0.001)* between the cohort girls' *(n=41)* mean science scores in Year 5 *(3.88)* and Year 6 *(3.16)*. There was no significant difference, however, between the girls' mean scores in Years 6 and 7 *(t=0.229, df=40, p=0.820)* or between Years 7 and 8 *(t=1.049, df=40, p=0.300)*.

5.4.2.(i) <u>*Boys' scores*</u>

For the boys *(n=30)*, however, the difference between the mean science scores in Years 5 and 6[2] was just significant but, between Years 6 and 7[3], and Years 7 and 8[4] there were no significant differences. The gender differences in the pupils' mean science scores over the 4-year period are shown in Fig. 5.30.

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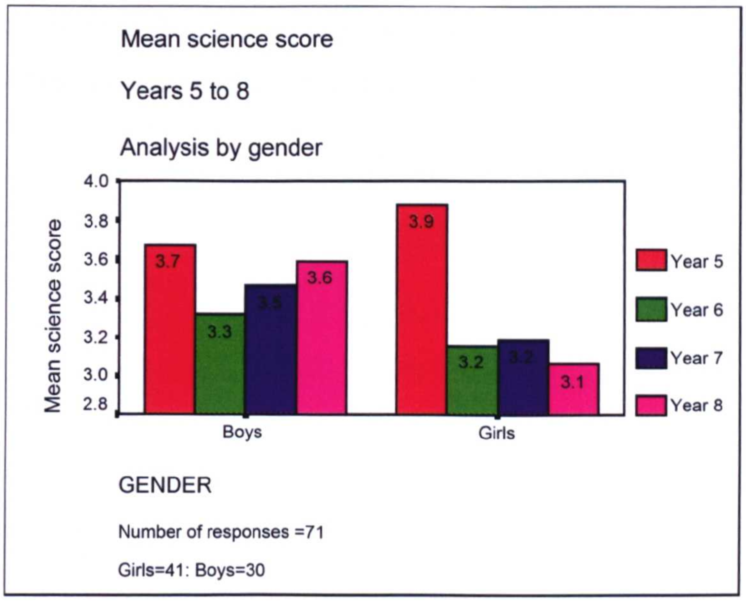
[1] Except the 'materials' topic in Years 5 and 6 – see 5.1

[2] *(t=2.057, df=29, p=0. 049)*

[3] *(t=0.818, df=29, p=0.420)*

[4] *(t=-0.902, df=29, p= 0.375)*

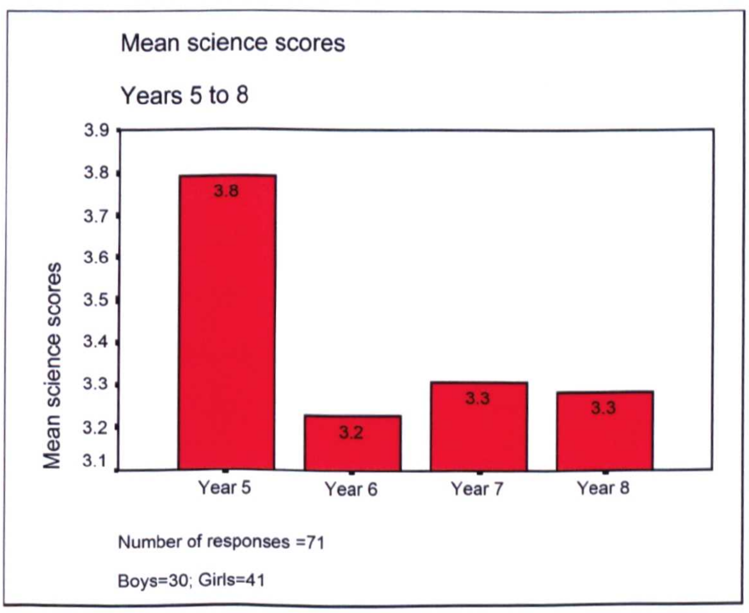
Fig. 5.30: Mean attitude scores to all science modules: Years 5 to 8
Analysis by gender



5.4.3 Cohort mean attitude scores between Years 5 and 8: analysis by gender

For the cohort pupils *(n=71)* there was a highly significant difference in the mean science scores between Years 5 and 6 (*t= 4.715, df=70, p= 0.001*). After transition, however, the cohort mean score rose in Year 7 (see Fig. 5.31) from *3.23* to *3.31 (t=0.738, df=70, p=0.463)* and remained almost at the same level, *3.28*, at the end of Year 8 *(t=0.237, df=70, p=0.813).*

Fig.5.31: Cohort pupils' mean science scores: Years 5 to 8



As well as the content of the science curriculum, other "in-school" factors such as the perceived difficulty of science, the pupils' perceptions of their performance in science and the quality of the pupil-teacher relationship may affect the pupils' attitudes to science - some of these other "in-school" factors are discussed in Chapter 6.

Chapter Five: "In-school" factors: the content of school based science

5.5 Summary

Quantitative and qualitative data on the pupils' attitudes to the **physical science** modules studied between Years 5 and 7 were presented. The popularity of the topics varied and there were statistically significant gender differences, in favour of the boys, in the mean attitude scores (see Appendix 5.1) for the Electricity and Magnetism modules in Years 6 and 7 and for the Forces module in Year 7.

Data were also presented for the pupils' attitudes to the **biological science** modules in Years 5 to 8. There was a lack of uniformity, particularly in the primary phase, in the content of the biological science topics and this presented difficulty, because of the small numbers of pupils studying some of the topics, in drawing year-by-year comparisons. Although the Year 5 data were drawn from only two schools, a lack of enthusiasm for biology seemed to have occurred, for both boys and girls, before the point of transfer and the negative attitudes, particularly of the boys, to plant sciences (the ecosystems module) continued to be demonstrated.

By Year 6, the boys (compared with the girls) showed a statistically higher mean attitude score to the physical sciences and this continued through Years 7 and 8. Significant differences were detected in the girls' attitudes to the physical and biological sciences in Year 6 and Year 7. Although the girls' preference for the biological sciences, compared with the physical sciences, was maintained in Year 8 the girls' mean scores for both categories fell slightly during the year and there was no significant difference between the two mean attitude scores.

Only in Year 8 was a significant gender difference (in favour of the boys) detected in the mean science scores. This was explained by the widening gap between the boys' and girls' attitudes to the physical sciences. The boys' lessening enthusiasm for the biological sciences was not as significant as the girls' increasingly negative attitudes towards the physical sciences (see section 5.3).

There was a highly significant drop in the mean science scores for the cohort between Years 5 and 6 followed by a significant rise in the mean score at the end of Year 7. The Year 7 mean score, which was lower that the mean score at the end of Year 5, then remained at approximately the same level during Year 8.

The girls' mean science score fell significantly *($p<0.001$)* between Years 5 and 6 (due mainly to the increasingly negative attitudes towards the physical sciences modules). However, neither the rise in the girls' mean score after transition, nor the subsequent fall in their mean score between Years 7 and 8, were statistically significant.

Between Years 5 and 6, the boys' mean science score fell but, after transition, the scores rose above the Year 5 level and, by the end of Year 8, there was a further increase in the score (due mainly to the increasingly positive attitudes to the physical sciences). The annual differences between the scores in Years 5/6, 6/7 and 7/8 were not statistically significant.

For Years 5 and 6, comparison of the cohort data *($n=71$)* with those of the complete year groups *($n=102$),* suggested that the pupils remaining in the final cohort were representative of the original year groups. Comparison of the Years 7 and 8 cohort data with those for pupils who had transferred to the comprehensive school from other (non-participating) primary schools were shown to be in good agreement with data derived from these other groups; this also suggested that the responses of the final cohort group were fairly typical of the year group as a whole.

Chapter Six: "In-school" factors: other aspects of science lessons

Introduction

In addition to an investigation of pupils' attitudes to the physical and biological sciences (Chapter 5), one of the research objectives was to see whether there were any links between these measures of pupils' attitudes to science and various other "in-school" factors.

The majority of these additional issues arose as a result of the literature review (Chapter 3) and included:

1. *The perceived difficulty of science*
2. *Perceived performance in science (compared with that in their favourite subject area)*
3. *The 'interest factor' of science lessons*
4. *The quality of the pupil-teacher relationship*
5. *Repetition of content*
6. *Writing and note-taking*
7. *Attitudes towards investigations/practical work*

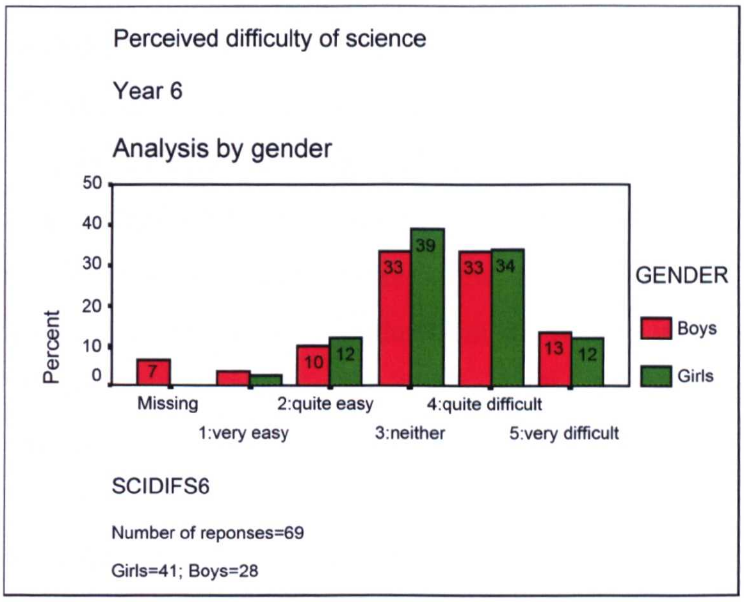
6.1 The perceived difficulty of science

In Year 5, the content of the various topics covered in the primary schools was not always clearly defined as 'science' or 'humanities' and so no attempt was made to assess pupils' perceptions of the difficulty of science until Year 6.

6.1.1 Year 6

The pupils were asked to score, on a 5-point scale, their views on the difficulty of science compared with other areas of study (Appendix 4.2, Question 6).

Fig. 6.1: Perceived difficulty of science: Year 6



The cohort[1] mean score for the perceived difficulty of science was *3.43*. There was no significant difference *(t= 0.209, df=67, p=0.835)* between the girls' mean score *(3.41)* and that of the boys *(3.46)* – see Table 6.1 – and the distribution of scores was similar for both the girls and the boys.

Table 6.1: Perceived difficulty of science

Group	All pupils		Boys		Girls		Significance
	mean	***SD***	***mean***	***SD***	***mean***	***SD***	*(independent samples t-tests)*
Year 6							
All pupils	3.44 *(n=100)*	0.95	3.35 *(n=48)*	1.02	3.46 *(n=52)*	0.94	*t(98)=-0.236, p=0.814*
Final cohort	3.43 *(n=69)*	0.96	3.46 *(n=48)*	1.00	3.41 *(n=52)*	0.95	*t(67)=0.209, p=0.835*

The tape-recorded interviews in Year 6 had offered the pupils an opportunity to comment on how science was perceived ('easier', 'about the same' or 'harder') compared with other subjects – a summary of the qualitative data is given in Appendix 6.2.

[1] The data produced by the cohort pupils were in general agreement with those generated by the pupils in the complete Year 6 group *(n=102)* before attrition.

In Year 5, there had been several comments (both positive and negative) which suggested (see Chapter 5.1) that the writing component of some modules influenced the pupils' attitudes to that module. In Year 6, four pupils made some link between the perceived difficulty of science and the writing component (see 6.5). One boy (UNW04), who felt that science was "quite difficult", commented that "you have to do a lot of ritting (writing)" whereas another boy (OLU03), who felt that science was "very easy", supported his choice of score with "you only have to write a few words". The link between the level of perceived difficulty of science and the enthusiasm for writing was also commented on by a girl (OLN05) who felt that science was "quite easy" – her explanation: "because I find writing up things easy".

The Year 6 questionnaire (Appendix 4.2, Question 9) enquired whether pupils thought that science would be different in any way in their 'new' school. Ten boys and 12 girls expected the secondary science lessons to be 'harder' or 'more difficult' but in only a couple of cases did this appear to raise any concerns:

Girl
OLN06 "They might be harder and less interesting"

Boy
XLI19 "science gets harder every year"

The reported difficulty of science did not, however, seem to be a major negative influence on the pupils' liking for science, there was a moderate positive correlation *($r=0.400$, $p<0.01$)* between the two measures. There were also correlations between the perceived difficulty of science in Year 6 and attitudes to investigations *($r=0.337$, $p<0.01$)*, the choice of science as a favourite subject in Year 6 *($r=0.344$, $p<0.01$)* and the perceived performance in science in Years 7 and 8 *($r=0.260$, $p<0.05$* and *$r=0.318$, $p<0.01$* respectively).

6.1.2 Year 7

In Year 7, the pupils were also asked (Appendix 4.3, Question 10) to make any additional comments on whether they liked, or disliked, each of the 8 science modules covered during the year. Five comments were made, all by girls, which were linked with the perceived difficulty of the subject (Appendix 6.2). These 5 comments were, however, drawn from a total of 285 positive, neutral and negative comments over all the eight modules and therefore represented less than 2% of all the statements made in this section of the questionnaire. However, the absence of any comments from the boys may suggest that they are less willing to admit to any difficulties of understanding. Two of the girls (OLI03 and OLN07) had also responded to Question 9(b) which gave those pupils for whom science was not their favourite subject an opportunity briefly to explain the reasons for their negative attitudes. Out of the 67 comments from the cohort, only 2 pupils (both girls) made comments which were related to the subject's perceived difficulty:

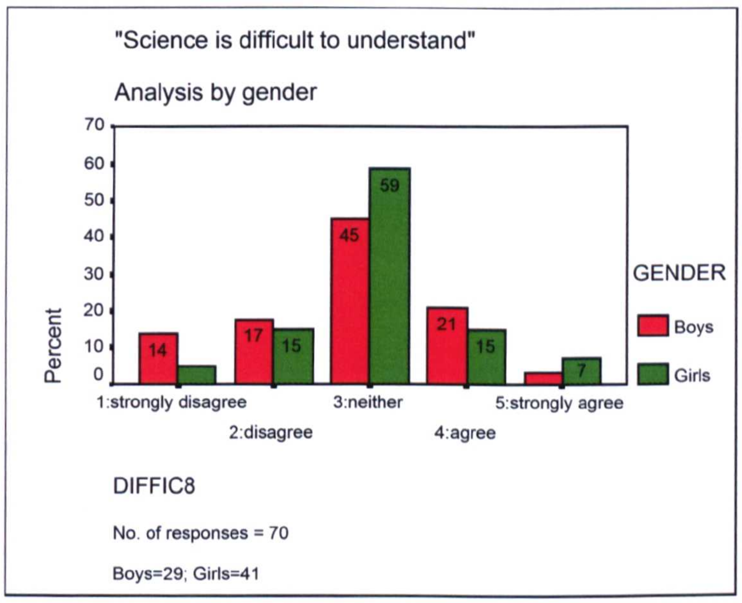
OLI03 "….I can't stand it. v. complicated, sometimes interesting"

OLN07 "you don't do that many experiments it's hard to understand sometimes"

6.1.3 Year 8

The Year 8 questionnaire also gave an opportunity to comment on the difficulty issue - see Appendix 4.4, Question 4. The pupils were asked to score, on a 5-point scale, the strength of their agreement, or disagreement, with the comment "Science is difficult to understand".

Fig. 6.2: Perceived difficulty of science: Year 8



The responses were fairly evenly distributed around the central point of the scale (score 3: "neither agree nor disagree"); the cohort mean score was *2.96, SD 0.95*. The number of pupils who recorded scores at the extremes of the scale was very low; four (13.8%) of the boys, compared with only 2 (4.9%) of the girls, recorded strong disagreement with the statement. This suggests that the boys are less likely to perceive science as difficult or, possibly, that they are less willing to record their concerns. Only a very few pupils made comments which linked lack of understanding to the perceived difficulty of the subject but there were, however, weak, negative correlations between agreement with the statement and perceived performance in Year 8 *($r=-0.244$, $p<0.05$)*.

At the other end of the scale, 3 (7.3%) of the girls but only 1 (3.4%) of the boys, strongly agreed with the statement. Although the girls recorded a higher mean score (i.e. a greater agreement with the statement) than the boys (girls: *mean 3.05, SD 0.89*; boys: *mean: 2.83, SD 1.04*), there was no significant difference between the means *(t=-0.954, df=68, p=0.343).*

As in Year 7, an opportunity was provided on the Year 8 questionnaire (Appendix 4.4, Question 6) for pupils to record their negative feelings about science lessons and also to provide positive or negative comments (Question 7) on the three groups of modules (i.e. biology, chemistry and physics) which were studied during the year. An examination of the responses to Question 6 showed that, out of 159 miscellaneous comments, only 4 (2.5 %) were related to the understanding of the subject (Appendix 6.2).

One girl (UNW07) found the physics modules 'quite difficult' and one girl (OLN11) commented that the chemistry modules were 'a bit hard'. However, another girl (OLN07) reported that she liked the chemistry modules most because they were 'easier to understand'. The biology modules were felt to be 'difficult to understand' by only 2 girls (OLI03 and OLI08); no boys made any comments on the difficulty of any of the three types of modules.

6.1.4 Year 9

The opportunity to extend parts of the study into Year 9 (see Chapter 4) enabled some further questioning of the cohort pupils to take place at the end of the following summer term (1999). The pupils were asked (Appendix 4.5, Questions 1 and 2) to indicate which of the nine Year 9 modules they found most difficult to understand and, if possible, to try to explain their answers. Despite being asked to only name one module, several pupils gave multiple answers and so the data (see Appendix 6.2) should be interpreted with caution. Whilst the girls, compared with the boys, generally reported more difficulty with the physics modules, the chemistry modules (particularly Chemical Patterns) appeared to cause some problems for both sexes.

The pupils were also asked (Appendix 4.5, Question 1(d)) to record the single module which they found easiest to understand but, again, multiple answers were given and so this cannot necessarily be taken as an accurate reflection of the pupils' views. Reasons for citing the "easiest module to understand" gave little additional information but an element of repetition of earlier work seemed to be beneficial for several pupils (see Appendix 6.2);

the pupils' attitudes to repetition of content in science lessons is discussed in more detail at 6.5.

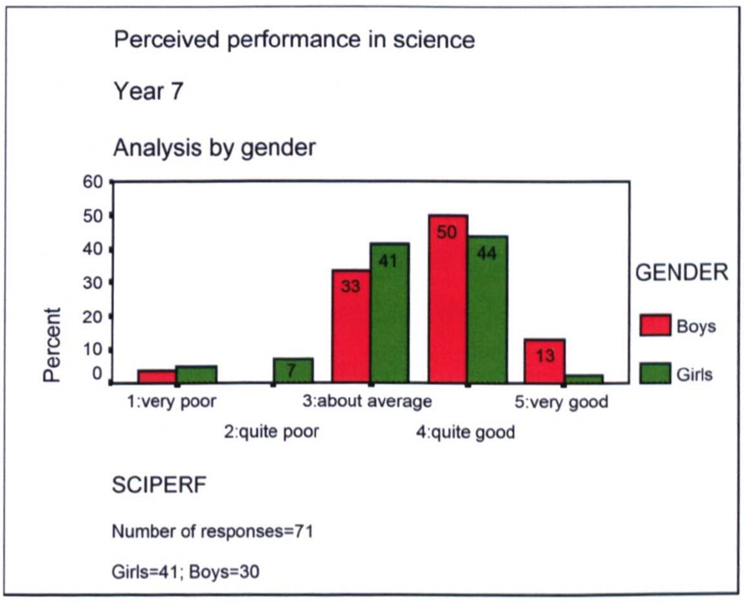
6.2 Perceived performance in science

In Year 6, the pupils had been asked about their feelings on the difficulty of science (see 6.1) but no attempt was made to compare their perceived performance in the subject area with that in, for example, humanities or mathematics.

6.2.1 Year 7

At the end of Year 7 the pupils were asked (Appendix 4.3, Question 8) to record, on a 5-point scale, how they felt about their performance in science during the past year.

Fig. 6.3: Pupils' perceived performance in science: Year 7

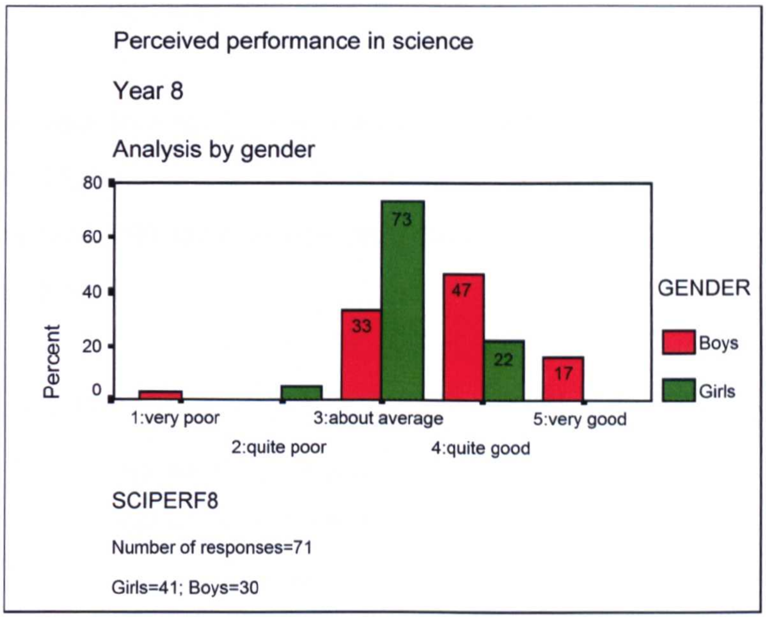


Just over 8 per cent of the pupils felt that their performance in science was either "very poor" (score:'1') or "quite poor" (score: '2'); 7% of the pupils in the cohort felt that it "very good" (score:'5'). The mean score for the cohort was *3.48*; there was no significant difference *(t=1.888, df=69, p=0.063)* between the boys' *(n=30)* and girls' *(n=41)* mean scores *(3.70, SD 0.84* and *3.32, SD 0.85* respectively).

6.2.2 Year 8

In Year 8, the pupils were also asked to record, on a 5-point scale, their perceived performance in science (Appendix 4.4, Question 5).

Fig. 6.4: Pupils' perceived performance in science: Year 8



The cohort mean score was *3.41, SD 0.73*. There was a significant difference *(t=3.456, df=69, p=0.001)* between the boys' *(n=30)* and girls' *(n=41)* mean scores *(3.73, SD 0.87* and *3.17 SD 0.50* respectively). Seventeen per cent of the boys felt that their performance in science during Year 8 was "very good" but none of the girls responded at this level. (In Year 7 there had been a negative 'tail' in the distribution of the girls' scores but, at that point, there was no significant difference between the boys' and the girls' mean scores).

As with their declaration about the 'difficulty' of science, the boys showed a more confident approach than the girls but it was not possible to ascertain whether their greater confidence was actually matched by their ability (indicators of actual performance were not considered in the study). By Year 8, however, the gender difference in scores, in favour of the boys, had become statistically significant *($p<0.01$);* weak negative correlations suggested a relationship between perceived difficulty and perceived performance *($r= -0.244, p<0.05$).*

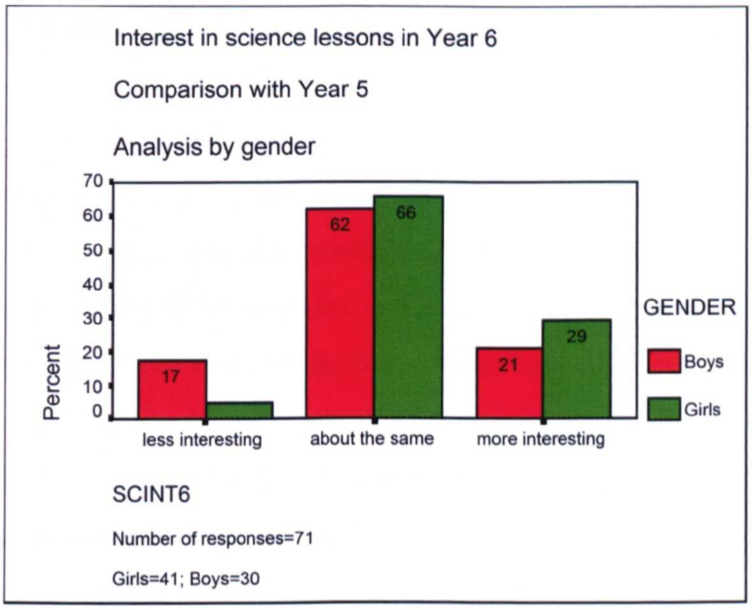
6.3 Attitudes to science lessons with respect to 'interest' factor

The literature review had demonstrated the close link between interest in a subject and the formation of positive attitudes towards that subject. In Years 5 and 6, comments were made by the pupils regarding their interest in different topics (rather than in 'science' as a whole) and these comments are recorded in Chapter 7. In Year 6, the questionnaire allowed for four different attitude measures to be derived from related, but slightly different, questions. One of these questions attempted to elicit the 'interest factor' of the Year 6 science lessons compared with those in Year 5.

6.3.1 Interest in science lessons: Year 6 compared with Year 5

Pupils were asked (Appendix 4.2, Question 5) to score, on a 3-point scale, whether they thought that, compared with the previous year, their science lessons had been more or less interesting than in Year 5.

Fig. 6.5: Interest in science lessons: Year 6 compared with Year 5



The cohort mean score was *2.16, SD 0.58, n=70*. The data might suggest that, compared with the boys, the girls were taking a slightly more positive interest in their science lessons at this stage but the difference in the girls' *(n=41)* and boys' *(n=29)* mean scores *(2.24, SD 0.54* and *2.03, SD 0.63* respectively) was not significant *(t=-1.500, df=68, p=0.138)*.

Examination of the qualitative data revealed that one boy (XLI03) felt that science was more interesting in Year 6 because "its got more challenging and harder"; a girl (XLD10) felt that it was more interesting because "last year it wasn't explained very well". Although a couple of pupils commented that they thought the Year 6 science was more interesting "because we done more exciting things" (OLN10, boy) or "because we do more grown up things" (UNW14, girl), in a few cases the increased interest of the science topics was linked by the pupils to their improved understanding of the subject matter (see Appendix 6.2).

A couple of pupils, who thought that the science was more interesting, commented that there had been an extension of activities but a large number (22) of those pupils giving less positive scores ("about the same" and "less interesting") gave comments which emphasised the repetition, rather than the extension, of the previous year's science work. With specific reference to the Year 6 pupils' anticipation of science in the 'new' school the questionnaire had asked the pupils (Appendix 4.2, Question 9) about their expectations and whether they thought that the science lessons in the comprehensive school might be different in any way. Ninety of the 100 pupils responding to this question thought that there *would* be a difference in science lessons and a frequent reference, by both boys and girls, concerned the chance to use different, or better, equipment in the secondary school. Virtually all the comments assumed that 'science' meant the *physical* sciences and that the major difference would be the availability of "better" or "complicated" equipment (see Appendix 6.5).

Several other pupils, mostly girls, linked the use of more, or better, equipment with an anticipation that their science lessons would be more 'interesting' and one girl (XLD06) thought that the availability of laboratories at the secondary school would mean that "you can 'do' things and not sit and write all the time". Four boys and four girls commented that they would be using "chemicals" or doing "things like Chemistry" (UNW10, a girl). One boy (OLI04) specifically mentioned 'bunsen burners' but, despite the large number of comments which anticipated more interesting science lessons, only two pupils (one boy, OLU05, and one girl, OLN02) thought that their science lessons would be more 'exciting':

Girl
OLN02 **"I think they will be more exciting and we will get to use real chemicals"**

One girl (XLD11) was succinct in her comment: "It will be more fun."

6.3.1 Comparison between School OL and Schools XL and UN

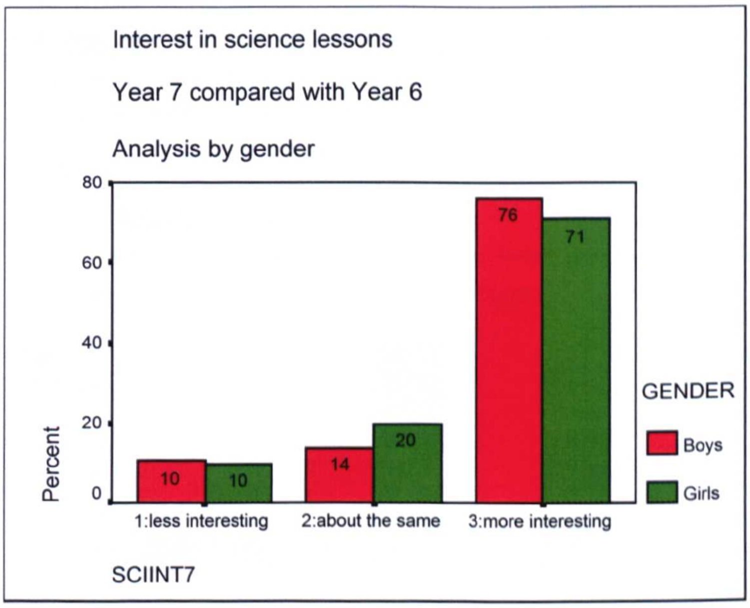
It was possible that the pupils in School OL (where the Year 5 and Year 6 pupils were taught together in 3 vertically grouped classes) might perceive that there was more repetition between Years 5 and 6 compared with that experienced by the pupils in the other two schools (Schools XL and UN). Further examination of both the qualitative and quantitative data, however, revealed that the pupils *(n=22)* from School OL had, in fact, recorded an almost identical mean score for the 'interest factor' to that of the pupils *(n=47)* from the other two Schools UN *(2.17)* and XL *(2.15)* taken together; there was no significant difference between the means *(t=0.168, df=68, p=0.867)*.

6.3.2 Interest in science lessons: Year 7 compared with Year 6

In Year 7, pupils were also asked (Appendix 4.3, Question 12) to compare their interest in science lessons in Year 7 with that during the previous year. For over 70 per cent of both boys and girls it appeared that the Year 7 work had positively stimulated their interest, only 10 per cent of the boys (and a similar percentage of girls) felt that the work was less interesting (see Fig. 6.6).

There was no significant difference *(t= 0.280, df=68, p=0.780)* between the boys' and girls' means (*2.66* and *2.61* respectively).

Fig 6.6: Interest in science lessons: Year 7 compared with Year 6



In Year 7, interest in science compared with Year 6, showed a moderate correlation with the mean attitude score to the physical sciences *(r=0.329, p<0.01)* and a good correlation with the pupils' attitudes to investigations *(r=0.498, p<0.01)*. Weak correlations were suggested between the score for interest in science and the mean score for the biological sciences *(r=0.262, p<0.05)*, the pupils' attitudes about asking questions *(r=0.239, p<0.05)*, their perceptions of the quality of their relationship with the science teacher *(r=0.270, p<0.05)* and the perceptions of their ability in science *(r=0.292, p<0.05)*.

6.3.3 Comparison of Year 7 data: cohort and non-cohort pupils

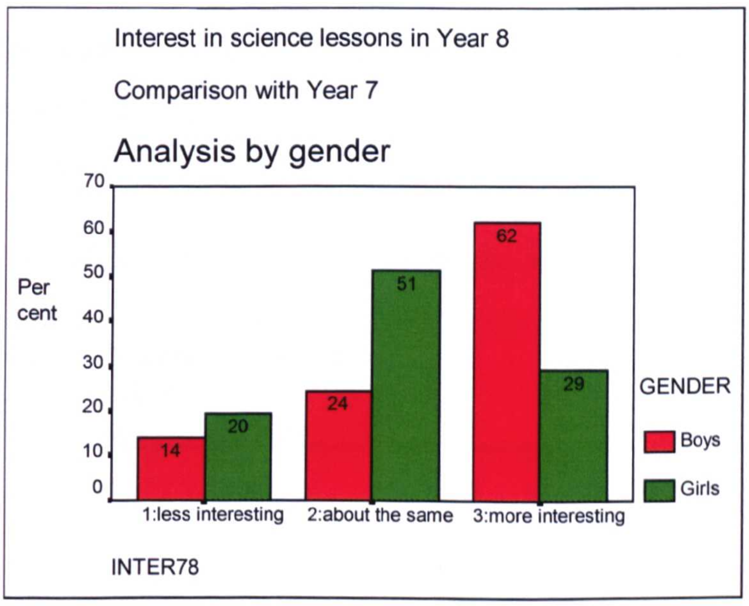
The cohort pupils' *(n=70)* responses on their interest in science lessons in Year 7 compared with Year 6 were compared with those of the non-cohort pupils *(n=77)* in Year 7 who had joined the comprehensive school from various primary schools not participating in the study. There was no significant difference *(t= 0.707, df=145, p=0.481)* between the means of the cohort and non-cohort pupils (*2.63* and *2.55* respectively).

As with the cohort pupils, there were no significant gender differences between the Year 7 non-cohort boys' and girls' mean scores for interest in science lessons in Year 7 compared with Year 6. Nor were there any significant differences, for either the boys or the girls, between the mean scores for interest factor in the cohort and the non-cohort pupils.

6.3.4 Interest in science lessons: Year 8 compared with Year 7

Question 8 of Appendix 4.4 gave the pupils an opportunity to record, on a 3-point scale, their interest in science in Year 8 compared with that in the previous year.

Fig.6.7: Interest in science lessons: Year 8 compared with Year 7



The percentage of boys (62%) who thought that science in Year 8 was more interesting than in Year 7 was more than twice that of the girls (29%) who agreed with this statement. There was a significant difference between the mean attitude score for the boys *(2.48, SD 0.74, n=29)* and that for the girls *(2.10, SD 0.70, n=41)*. The modal score for the boys was '3' ('more interesting'); for the girls the modal score was '2' ('about the same').

In Year 8, comments about the pupils' attitudes to science lessons were made in response to Questions 6 and 7 of the questionnaire – see Appendix 4.4. Examination of the responses indicated that the overwhelming reason for a positive attitude to science lessons was the practical work (this is discussed in more detail in 6.6). Out of 174 comments there was only one comment (UNW01, a boy) which specifically mentioned the interest factor but there were several comments about issues which probably sustained the pupil's interest e.g. "finding out things" (UNW16, a boy), "extends knowledge" (OLI02, a girl) and "class discussions" (UNW06, a girl).

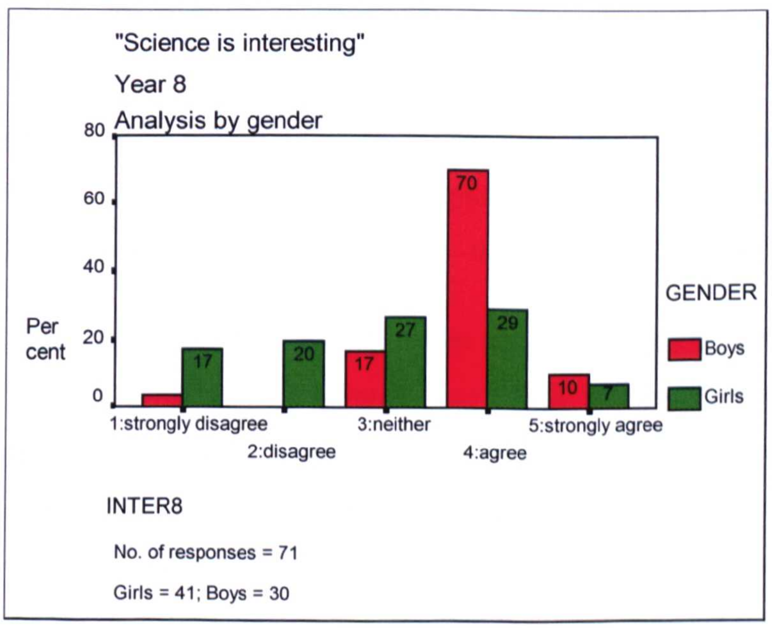
6.3.5 Comparison of Year 8 data: cohort and non-cohort pupils

In Year 8 the responses provided by the cohort pupils *(n=70)* were compared with those for 34 of the non-cohort pupils. There was no significant difference *(t=-1.213, df=102, 0.228)* between the mean attitude scores of the cohort and the non-cohort pupils *(2.26, SD 0.74* and *2.44, SD 0.70* respectively); nor was there any significant difference between the mean boys', or the mean girls', scores in the two groups.

6.3.6 Science is interesting? Science is boring?

In Question 4 (Appendix 4.4) the Year 8 pupils were asked to record, on a 5-point scale, their agreement (or otherwise) with eight statements about science lessons. Two opposing statements which were included were "Science is interesting " (4.1) and "Science is boring" (4.3) – see Fig. 6.8.

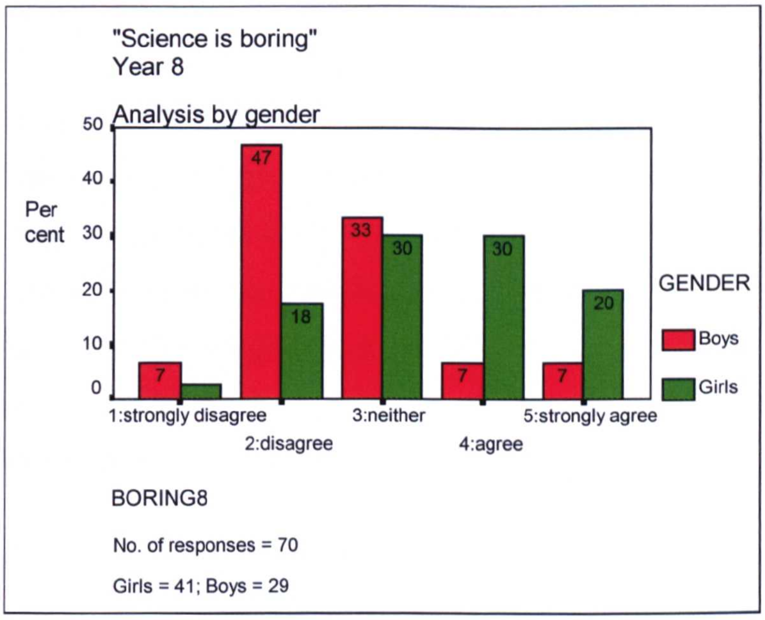
Fig. 6.8: Responses to the statement: "Science is interesting"



The cohort *(n=70)* mean score for agreement with the statement: "science is interesting" was *3.29, SD 1.14* (strongly disagree= '1'; strongly agree= '5'). The boys' *(n=29)* mean score was *3.83, SD 0.75* and the mean score for the girls *(n=41)* was *2.90, SD 1.22*; there was a statistically significant difference *(t=3.697, df=69, p=0.001)* between the two means.

The cohort *(n=70)* mean score for agreement with the opposite statement: "science is boring" (see Fig. 6.9) was *3.10, SD 1.12*. The boys' *(n=29)* mean score was *2.60, SD 0.97* and, for the girls *(n=41)*, the mean score was *3.48, SD 1.09*. There was a significant difference *(t=-3.492, df=68, p=0.001)* between the two means – the boys showing more disagreement with the statement than the girls.

Fig. 6.9: Responses to the statement: "Science is boring"



There was a strong negative correlation *(r=- 0.714, p=0.001)* between the scores for the opposing statements - the girls recording a higher negative correlation between their statements *(r=-0.746, p=0.001)* than the boys *(r= -0.477, p=0.008)*.

In the middle of the range (score '3'), twenty-seven percent of the girls neither agreed, nor disagreed, with the statement "science is interesting". This is very close to the percentage (30%) of girls who neither agreed, nor disagreed, with the alternative statement: "science is boring". However, only 17% of the boys appeared to have neutral attitudes to the statement "science is interesting" but almost twice this percentage (33%) of the boys demonstrated neutral attitudes to the opposing statement ("science is boring"). This may demonstrate a higher expectation, by the boys, of more interesting or exciting activities.

This inconsistency was repeated in the boys' positive responses (scores '4' and '5' taken together) to the statement "science is interesting" - eighty per cent of the boys agreed, or strongly agreed, with this statement but more than half (54%) of the negative ('1' and '2' scores taken together) also reported that "science is boring". This may suggest that, if presented with a negative statement which includes the word 'boring', boys will go along with it even though they also have some positive attitudes – perhaps their interpretation is that science doesn't meet their *expectations.*

Whereas 36% of the girls agreed, or strongly agreed, with the statement "science is interesting", only 20% of the girls *disagreed* (or *strongly disagreed*) that "science is boring" and almost half of these girls confirmed their views by *agreeing* with the statement that "science is interesting".

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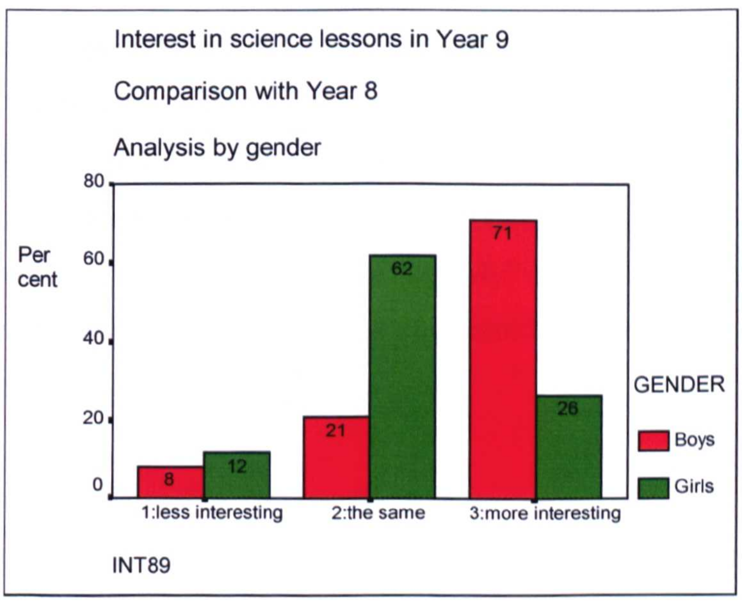
6.3.7 Interest in science in Year 9

The additional Year 9 questionnaire included a similar question about the interest factor of Year 9 science lessons compared with Year 8 (Appendix 4.5, Question 4). Fifty-eight pupils (24 boys, 34 girls) from the final cohort answered the question on this additional questionnaire (Fig. 6.10). For these 58 pupils the mean was *2.34, SD 0.66.* The difference between the boys' *(n=24)* mean *(2.63, SD 0.65)* and the girls' *(n=34)* mean score *(2.15, SD 0.61)* was highly significant *(t=2.867, df=56, p=0.001).*

Fig.6.10: Interest in science lessons: Year 9 compared with Year 8



6.3.8 Most interesting' and 'least interesting' modules: additional Year 9 data

The extension of the study to cover Year 9 (see Chapter 4.13) allowed some extra questions to be asked. The pupils' attitudes to the different groups of modules (biology, chemistry and physics) had been sought in Year 8 in order to compare attitudes towards the biological and physical sciences; in Year 9 some questions were asked about attitudes to individual modules. The pupils were asked to record which one of the nine science modules they had studied that year was the most interesting and also which one was the least interesting (Appendix 4.5, Questions 1(a) and 1(b)). Several pupils gave multiple answers however and so the data analysis cannot necessarily be regarded as an accurate reflection of the pupils' views on this issue; where more than one module was named, the first cited module was recorded.

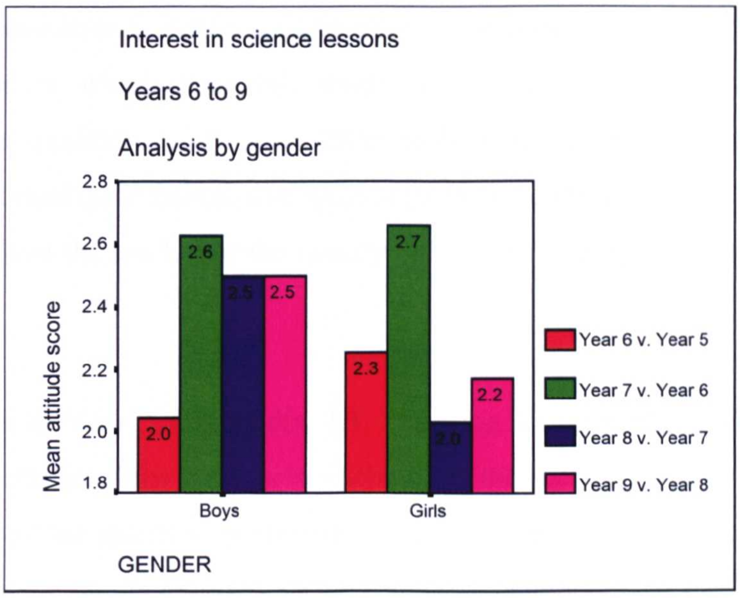
Whilst little statistical significance can be attached to these additional data (see Appendix 6.2), it would seem that a majority of the girls considered the biology modules to be *most* interesting; the boys' lack of enthusiasm for the ecosystems module was very much in line with other data obtained during this study (see Chapter 5.2). Although the boys' dislike of ecosystems was perhaps predictable in view of the comments in the literature (Ormerod and Duckworth, 1975; Ormerod, 1975b; Kelly, 1986 and Murphy and Beggs, 2003), the data differ from expectations based on the responses to the question about the "most interesting" module particularly regarding the girls' attitudes to ecosystems. However, in general terms, the data would seem to support the suggestions made in Chapter 5 that the girls demonstrated more negative attitudes than the boys to the physical science modules.

Examination of the qualitative comments (Appendix 4.5, Question 2) revealed some pointers as to what influenced pupils' perceptions of the 'interest factor' of a module (see Appendix 6.2). Other comments which were linked with pupils' views about least interesting modules included the writing content: "we did lots of writing" (OLI04, a boy) and " there was no practical and too much writing" (XLD06, a girl) and the quality of the teacher's explanation: "it was not explained clearly" (XLD23, a boy). The pupils' perceptions of their teacher's ability to explain scientific concepts and the relationship between pupil and teacher is discussed in 6.4.

6.3.9 Interest in science Years 6 to 9: a comparison

At the end of each year of the study, the pupils were asked to record, on a 3-point scale, whether they thought that their science lessons had been 'more interesting', 'about the same' or 'less interesting' during that year compared with the previous year. Using the additional data provided by the Year 9 questionnaire a comparison was made of pupils' attitudes over the five-year period.

Fig. 6.11: Interest in science lessons: Years 6 to 9



For both boys and girls there was an increasing interest in science lessons on transfer to secondary school and a fall, particularly by the girls, between Years 7 and 8. For the boys there was virtually no change between Years 8 and 9 although the girls reported some improvement (from the decline in attitudes between Years 7 and 8) in Year 9.

6.3.10 Interest in science lessons: Gender comparisons

6.3.10 (i) Girls

Examination of the data for the girls' *(n=40)* interest in science lessons (compared with the previous year) seemed to reflect the pattern demonstrated by their mean attitude to science scores[2] – see Chapter 5.4. There was a significant improvement in interest between Years 6 and 7 *(t=-3.056, df=40, p=0.004)* with only 4 girls reporting that the lessons were less interesting during Year 7 compared with Year 6. There was a fairly even distribution of the girls' responses between the 'more interesting' scores (19 responses) and 'about the same' scores (18 responses) to the question on interest factor.

6.3.10 (ii) Boys

The boys' *(n=28)* interest in their science lessons between Years 6 and 7 had increased significantly *(t=-3.360, df=27, p=0.002)* – only three boys reporting that the Year 7 lessons were *less* interesting than those in Year 6. Seventeen boys thought that the lessons were *more* interesting than in Year 7 and eight boys felt that the interest factor was about the same.

[2] averaged over all science modules

6.4 The quality of the pupil-teacher relationship

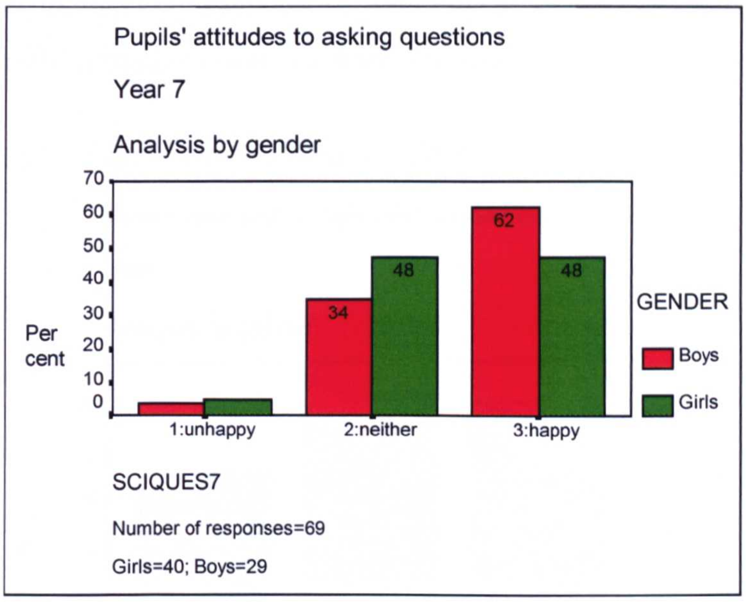
The annual questionnaires also gave an opportunity for pupils to comment at various points on any other issues which they felt might affect their feelings about science. An examination of the qualitative data collected by the end of the primary phase suggested that the pupils often linked their attitudes to lessons (both in science and in other subject areas) with comments about the teacher or the quality of his/her teaching (see Chapter 3).

6.4.1 Year 7

The questionnaire in Year 7 (Appendix 4.3, Question 13) specifically sought comments about the pupils' relationships with their teachers. At the secondary school, for timetabling reasons, very few of the pupils in the lower school were taught science by only one teacher during the year; some pupils had two, or even three, teachers during the 2-week timetable. The pupils also made several comments in response to Question 9 (which sought explanations about the pupils' likes, or dislikes, about science). Eight (out of 60) responses included (mainly) negative comments about the teacher; there was one positive comment (from a girl) and this was given as the main reason for the pupil regarding science as her favourite subject (see Appendix 6.2).

The two-part Question 13 (Appendix 4.3) sought, more specifically, to quantify the Year 7 pupils' views about the relationship with their teacher(s). It was assumed that a pupil who had a good relationship with a teacher would feel able to ask that teacher questions and so a pair of questions (see Fig. 6.12 and 6.13) aimed to elicit some additional information on "in-school" issues and was therefore included at the end of the questionnaire. Although there was some concern that some pupils might not be able to complete the questionnaire in the allotted time, only two pupils (one boy and one girl) in the cohort did not provide responses to these questions.

Fig. 6.12: Pupils' attitudes to asking questions: Year 7



Although a higher percentage of boys (62%) than girls (48%) reported that they had no worries about asking questions of their science teacher, there was no significant difference *(t=1.133, df=67, p=0.261)* between the mean attitude scores for the boys *(2.59, SD 0.57, n=29)* and the girls *(2.42, SD 0.59, n=40)*.

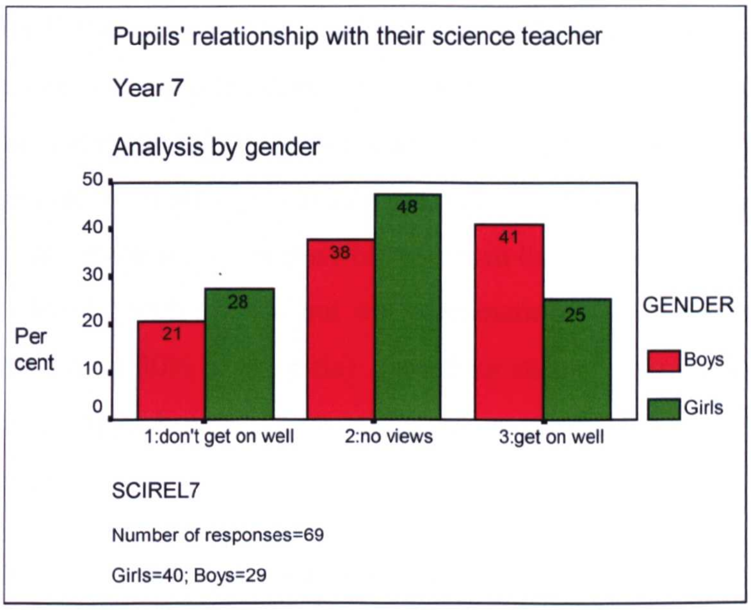
In Year 7 some of the pupils had more than one teacher for science and so these responses must be interpreted with caution; the responses are unlikely to reflect an attitude to an individual teacher but rather to a more general pupil-teacher relationship.

Two of the girls qualified their responses with comments which suggested a negative attitude towards their teacher: "It's boring and I hate Mr X" (OLU09); "boring, don't like teacher, all you do is copy" (UNW10). Four boys (16% of the boys responding to this question) and six girls (17% of the girls responding to the question) recorded negative attitudes about the teacher or his/her teaching style.

Two boys volunteered comments in their tape–recorded interviews which were linked to the pupil-teacher relationship. The verbal responses from one boy (OLU11) were exactly in line with the score recorded on the written questionnaire; the other boy (XLI12) had verbally agreed that he was happy about asking his science teacher for help, but he had given a neutral response on the written questionnaire. Although the distribution of the data (see Fig. 6.13) might suggest that the girls felt that they did not have as good a relationship with their science teacher as the boys, there was no significant difference *(t=1.267, df=67, p=0.210)* between the boys' and girls' mean scores *(2.21, SD 0.77, n=29* and *1.98, SD*

0.73, n=40 respectively). There was a statistically significant moderate correlation *(r=0.342, p=0.005)* between the quality of the pupils' perceived relationships with the teacher and the pupils' attitudes towards asking questions of their science teacher.

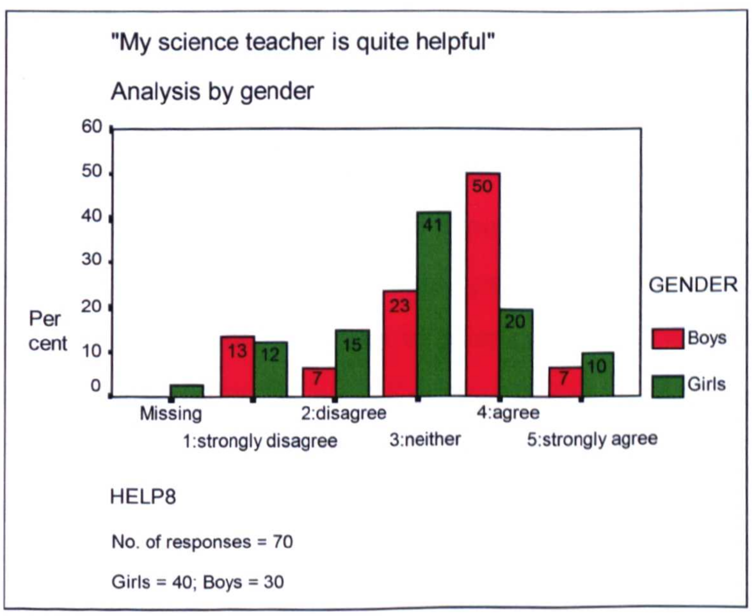
Fig. 6.13: Pupils' relationship with their science teacher: Year 7



6.4.2 Year 8

In Year 8 there was another opportunity to comment (Appendix 4.4, Question 4) on the nature of the pupil-science teacher relationship. Using a 5-point scale, the pupils were asked to score the statement: "My science teacher is quite helpful" (see Fig. 6.14).

Fig.6.14: Helpfulness of the science teacher: Year 8



The cohort mean score for agreement/disagreement with the statement was *3.13, SD 1.14, n=70*. For the boys (*n=30*) the mean score was *3.30, SD 1.15* and, for the girls, the mean score was *3.00, SD 1.13, n=40*. There was no significant difference *(t=1.090, df=68, p=0.280)* between the two means; the modal score for the boys was '4', for the girls it was '3'.

Although the pupils in Year 8 would normally be taught in mixed ability groups by one science teacher for the whole year, for staffing reasons the teaching of some of the Year 8 groups was shared between two teachers. This meant that, in some cases, the responses of some pupils to the statement: "My science teacher is quite helpful" may have referred to one of two teachers or, alternatively, it may have reflected an overall impression of *both* of their science teachers. Because of the possible errors in the responses, any interpretation of the data should be treated with caution but an examination of the responses suggested that 57% of the boys (but only 30% of the girls) agreed or strongly agreed, with the statement. In Year 7, 41% of the boys, but only 25% of the girls reported that they "got on well" with their science teacher.

Question 6 of the Year 8 questionnaire allowed the pupils to comment on three things which they liked, and three things which they disliked, about science lessons. Six pupils (four girls and two boys) made positive comments about their teacher e.g. "we have a laugh with the teachers" (XLD09, a girl); "the teacher is good" (UNW01, a boy) or "Mr. X helps a lot" (XLD02, a girl). The teacher, or his/her disciplinary style, was criticised by 5 boys (16.6% of the boys) and 14 girls (34.1% of the girls). Only six pupils had recorded positive comments about their teacher.

6.5 Repetition of content

6.5.1 (i) *Year 6*

By Year 6 it was clear from the qualitative comments, both on the questionnaires and in the semi-structured interviews, that some of the pupils felt that there was significant repetition of content in some areas e.g. biology, particularly food chains. Of the 67 comments made by pupils about their interest in science during Year 6, sixteen pupils (4 girls, 12 boys) referred to repetition. By now, Key Stage 2 tests in Science were part of the Year 6 schedule and 'revision' (see Appendix 6.8) now began to take on an examination-orientated flavour.

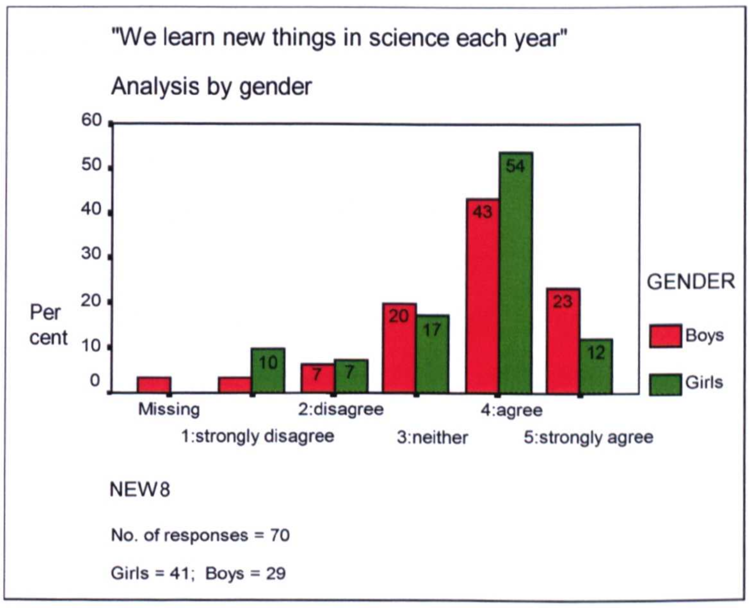
6.5.1 (ii) *Year 7*

Although, at the end of Year 7, comments made in response to the request to explain why science was not the pupil's favourite subject (Question 9, Appendix 4.3) lacked much detail beyond "it's boring", two cohort pupils (XLI20, a girl and XLD19, a boy) did provide comments which referred to repetition (the latter was confirmed in the transcript of the tape-recorded interview).

6.5.1(iii) Year 8

In Year 8, following on from the comments made by pupils in Years 6 and 7 about the apparent repetition of the content in science lessons, the pupils were asked for their views on two statements: "We learn new things in science each year" and "We study the same things in science each year" (see Figs. 6.15 and 6.16).

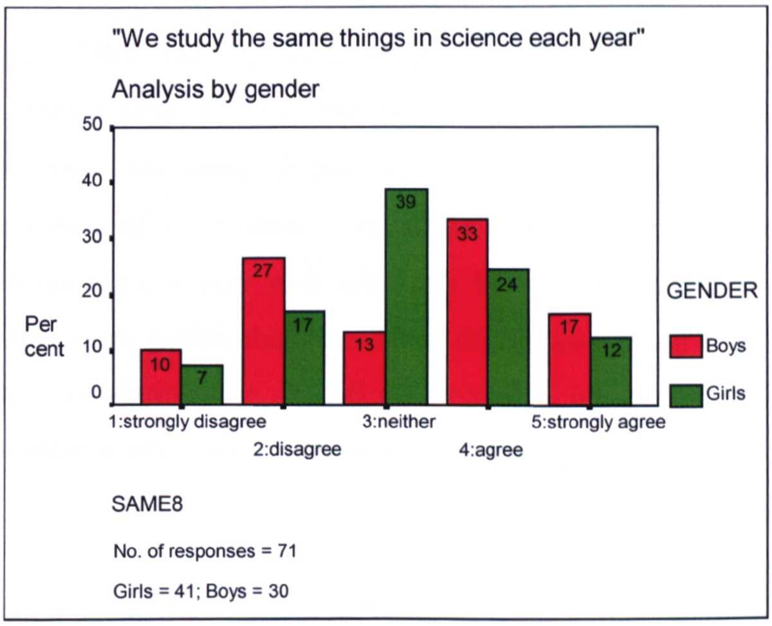
Fig.6.15: Responses to "We learn new things in science each year": Year 8



The cohort mean score for agreement with the statement: "we learn new things in science each year" was *3.63, SD 1.08.* The boys' *(n=29)* mean score was *3.79, SD 1.01* and, for the girls *(n=41)*, the mean score was *3.51, SD 1.12*; there was no significant difference *(t=1.074, df=68, p=0.287)* between the two means.

The cohort mean score for agreement with the statement: "we study the same things in science each year" (Fig.6.16) was *3.18, SD 1.17.* The boys' *(n=30)* mean score was *3.20, SD 1.30* and, for the girls *(n=41)*, the mean score was *3.17, SD 1.09*; again there was no significant gender difference *(t= 0.103, df=69, p=0.918).*

Fig.6.16: Responses to "We study the same things in science each year": Year 8



For the cohort as a whole, there was a statistically significant negative correlation *(r = -0.416, p=0.001)* between the mean scores for the two statements. For the boys, there was also a significant negative correlation *(r= -0.563, p=0.001)* between their responses to the two statements. For the girls, however, the negative correlation was slightly weaker *(r=-0.318, p=0.043)* which might suggest a lower level of consistency in their reported views.

Repetition attracted negative comments from two boys but five boys and six girls made positive comments (Question 6) about science in Year 8 (see Appendix 6.2). In the middle of the range (score '3' = "neither agree, nor disagree"), approximately the same percentage of boys (20%) and girls (17%) neither agreed, nor disagreed, with the statement "we learn new things in science each year". The percentages of boys and girls recording positive scores ('5' and '4' taken together) to the statement were identical (66% in both cases).

It seemed that the boys were more prepared than the girls to express an opinion, in either direction, to the statement: "we study the same things in science each year"; a large percentage (39%) of the girls simply recorded neutral scores ("neither agree, nor disagree"). The skew of the data for both sexes in Fig. 6.15 would suggest that many of the pupils do think that "new" material is offered each year. It does not, however, differentiate between material which the pupils perceive as 'new' because it is *different* (i.e. the content is taught by a different teacher in a different way) and material which is actually presented at a higher level of difficulty.

This lack of precision may explain the moderate correlation *(r=-0.416)* between the cohort responses to this statement: "We learn new things in science each year" and the opposing statement: "We study the same things in science each year" (Fig. 6.20). The fairly even distribution (Fig. 6.16) of the pupils' responses might be due to the pupils' wider interpretations of 'the same'. It may well have been understood to mean "the same *topics*" and the nature of the science curriculum is such that topics, or modules (e.g. 'ecosystems') do occur each year with relatively little change in name or title; it could therefore appear to most pupils that 'the same things' *are* being studied each year. A stronger negative correlation *(r= -0.714*) was recorded, however, between the opposing statements of "science is interesting" and "science is boring".

6.5.2 Year 9

Perceived repetition seemed to remain an issue in Year 9. The additional questionnaire asked the pupils (Appendix 4.5, Question 3(e)) to record which, if any, of the 9 modules covered a lot of the Year 8 work. Both the boys and the girls seemed to think that there was a lot of repetition in the physics modules although this may have been a lack of understanding that some new learning objectives had been added; this may also be the reason for the large number of girls reporting repetition in the Body Maintenance module.

6.6 Writing and note-taking

6.6.1 Year 5

In Year 5 some pupils had been critical of the amount of writing involved in, for example, the space and the materials modules where relatively little practical work was offered (see Chapter 5.1). However, whilst three boys (and one girl) complained about the amount of writing involved, one boy (XLD23) admitted to enjoying "writing about space monsters and aliens." In the materials module, neither girls nor boys seemed to enjoy the writing; one boy (UNW05) commented: "to much righting" and there were almost identical negative comments from another boy (UNW09) as well as from two girls (UNW14 and UNW27).

6.6.2 Year 6

In Year 6, four comments about the writing content of science topics were recorded in answer to Question 6 (Appendix 4.2) concerning the pupils' views on the difficulty, or otherwise, of science. Three of these comments were from boys (UNW04, XLD14 and OLU03) and all three regarded writing as a chore: "because you have to do a lot of ritting (writing)". The girl (OLN05) explained that she found "writing up things easy". It would seem that, for her, the opportunity to do some writing had, at least in part, influenced her perceptions that science was "quite easy" (score '4').

In Years 5 and 6, negative comments about the amount of writing involved in certain modules were almost all related to situations where, in the absence of practical work, the lesson time was occupied with significant amounts of writing. The observations may well have been disguising a lack of variety in the module rather than a simple distaste for writing itself. Whilst the girls were generally more tolerant of (and in some cases positively enjoyed) a greater writing load, the distaste for writing (particularly when there was little practical work) was later demonstrated in Years 7 and 8, particularly by the boys.

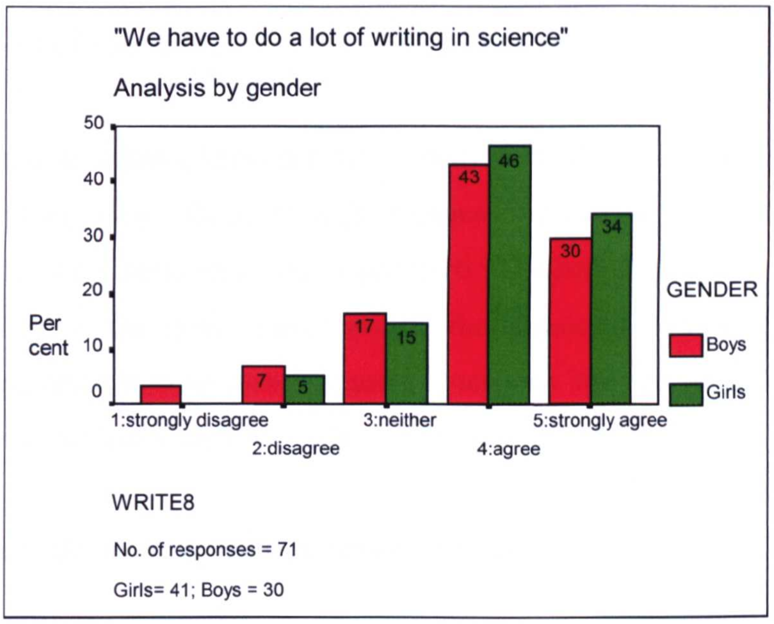
6.6.3 Year 7

By Year 7, as the primary school topics became more clearly differentiated into science and non-science modules, only three pupils (XLD22, a boy; XLI15 and OLI03, both girls) volunteered comments about the writing involved in relation to the individual science modules. Although two girls admitted that either they didn't like "doing experiments" or that they didn't like "all of the exparments" (XLD11 and OLU12 respectively), the main emphasis of the pupils' (particularly the boys') comments was of the imbalance between the 'writing' (too much) and the 'practical' (too little) components. The girls did have other negative comments about writing. On being asked (in a tape-recorded interview) why she did not want to be a scientist, one of the girls (XLD05) had commented "because you have to do all sorts of things like writing, and things like that, I like practical things." Another girl (XLD03) commented: "English is my best subject because I can think about what I am writing and not write what someone else is telling me to write". Although most of the comments about science lessons in general referred to the dislike of 'copying' (particularly from the board), several of the more detailed qualitative comments implied that it was the lack of freedom in the content and the style of the writing which distinguished 'writing' in science lessons from, specifically, 'writing' in English lessons. Generally, in Year 7, it was the lack of practical work which was the main source of complaint; the writing was not a major issue for the vast majority of the pupils.

6.6.4 Year 8

In view of the comments about writing which were being made in Year 7, the statement "We have to do a lot of writing in science" was included (Appendix 4.4, Question 4.8) on the Year 8 questionnaire – see Fig. 6.17.

Fig.6.17: Writing in science: Year 8



The cohort mean score was *4.01, SD 0.92* and, for both the boys and the girls, the modal score was '4' ('agree'). There was no significant difference *(t=-0.894, df=69, p=0.374)* between the boys' *(n=30)* and the girls' *(n=41)* mean scores *(3.90, SD 1.03* and *4.10, SD 0.83* respectively) and there was little gender difference between the percentages of boys and girls recording each of the scores. The qualitative data suggested that there was little change from the comments made, by both boys and girls, in Year 7 about writing and science. "Writing" was seen in a positive light by three girls (and no boys) in Year 8; five boys and eight girls commented positively on drawing/artwork/posters or "doing brochures". Eighteen boys and twenty girls, however, included "too much writing" in their negative comments about science and copying from the board, or from books, was mentioned by five boys and four girls.

6.6.5 Year 9

The additional Year 9 questionnaire, designed primarily to answer questions raised by the school science staff in order to inform teaching strategies and lesson planning, sought comments (Appendix 4.5, Question 3(i)) on whether, in the pupils' view, some of the modules had "too much written work". This was not an original objective of the research study but it did provide some additional information which was relevant to the study - multiple responses were permitted (see Appendix 6.9).

Whilst the boys' comments appeared to reflect their negative views to the biology modules, the girls also considered that the biology modules involved "too much writing".

In view of their relatively positive attitudes to the biological sciences (see Chapter 5.2) it would appear that, from the girls' point of view, the writing component was not necessarily a significant issue in formulating their attitudes to the subject area.

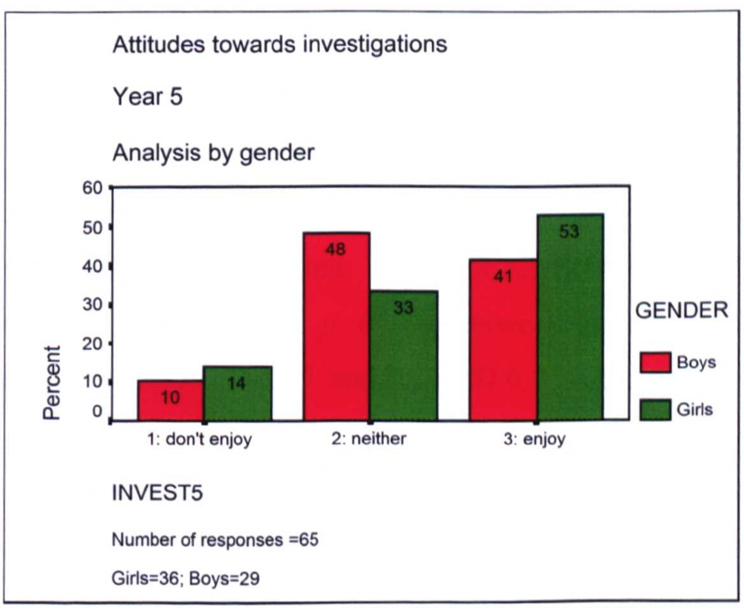
The pupils were also asked (Appendix 4.5, Question 3(h)), to record which of the nine modules had, in their view, about the right balance of practical and written work; again multiple responses were permitted (see Appendix 6.9). When the request was presented in a more positive way, the girls' comments on the physics modules seem to be quite encouraging. Responses to both these requests, Questions 3(i) and 3(h), were reflected by the data from the complete Year 9 *(n=180)*.

6.7 Attitudes towards investigations and practical work

6.7.1 Year 5

In Year 5 the pupils were asked to record on a 3-point scale their enjoyment of practical work and investigations (see Fig. 6.18). It was intended that the term "investigations" would cover a wide range of practical work, including relatively simple comparative tasks such as counting events or measuring volume, mass or time.

Fig.6.18: Attitudes to investigations: Year 5

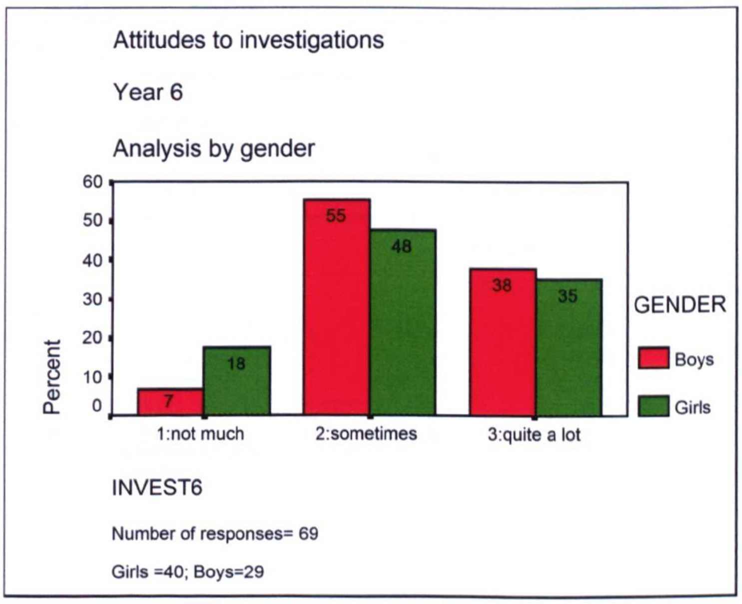


There were 65 responses (36 girls, 29 boys) and the mean score was *2.35, SD 0.65*. Out of those pupils responding, a higher percentage (53%) of the girls, compared with (41%) of the boys, recorded the most positive ('liked a lot') scores; the higher percentage of girls, compared with the boys, awarding the top score was reflected in the data from the entire year group[3] (50% and 40% respectively). There was no significant difference *(t= -0.450, df=63, p=0.654)* between the boys' (*n=29*) and the girls' (*n=36*) mean scores (*2.31, SD 0.66* and *2.39, SD 0.73* respectively); this was in good agreement with the data obtained from the complete year group (boys:*2.25, SD 0.67*, *n=47* and girls: *2.38, SD 0.68*, *n=48* respectively).

6.7.2 Year 6

In Year 6 the pupils were also asked (Appendix 4.2, Question 3) to record, using a 3-point scale, their attitudes to investigations (Fig. 6.19).

Fig. 6.19: Attitudes towards investigations: Year 6



The cohort mean score towards investigations was *2.23, SD 0.67*, (*n=69*); this was in very close agreement with that for the complete Year 6 *(2.22, SD 0.66, n=99)*. There was no significant difference *(t=0.830, df=67, p=0.410)* between the cohort[4] boys' *(n=29)* and girls' *(n=40)* mean scores *(2.31, SD 0.60* and *2.17, SD 0.71* respectively).

A significantly higher percentage of the cohort girls (18%), compared with the cohort boys (7%), recorded the most negative attitudes to investigations (score '1') and this pattern was reflected in the data for the entire year group. This might suggest that some of the girls had already formed fairly negative attitudes towards investigations by the end of Year 6.

[3] *n=95*

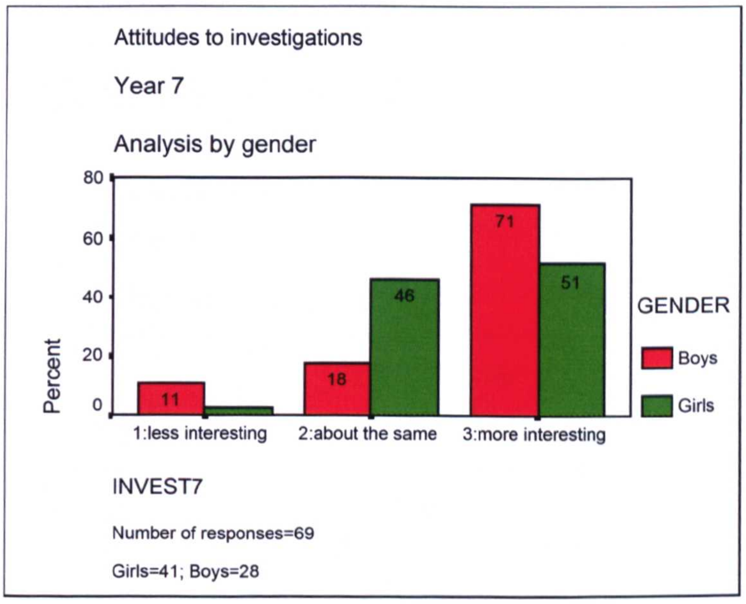
[4] This is in agreement with the responses from the full year group; no statistically significant difference was detected *(t=0.335, df=97, p=0.738)* between the boys' *(n=49)* and the girls' *(n=50)* mean scores *(2.24, SD 0.63* and *2.20, SD 0.70* respectively).

However, further examination of the raw data revealed that several of the 'investigations' did not necessarily involve practical work; the negative attitudes might have developed in response to the particular subject matter of these so-called 'investigations', rather than to a practical, investigative component.

6.7.3 Year 7

For many pupils, part of the excitement of the transfer to secondary school is the chance to use more sophisticated equipment (particularly the Bunsen burner) and these new opportunities are generally assumed to have a positive effect on pupils' attitudes at this stage. At the end of Year 7, the pupils were asked (Appendix 4.3, Question 11) to record, on a 3-point scale, their attitudes to investigations, see Fig. 6.20.

Fig. 6.20: Attitudes towards investigations: Year 7



Although there were clear gender differences in the distribution of the scores, with the boys generally showing more positive attitudes, the cohort *(n=69)* mean attitude score was *2.54, SD 0.61* and there was no significant difference *(t=0.798, df=67, p=0.428)* between the mean scores of the boys *(n=28)* and girls *(n=41)*.

Although the Year 7 boys showed a generally more positive attitude to investigations, the comments were not all favourable:

OLI09 "we dont do many experiments"

XLD21 "because you don't get to do a lot of exerments with chemicles"

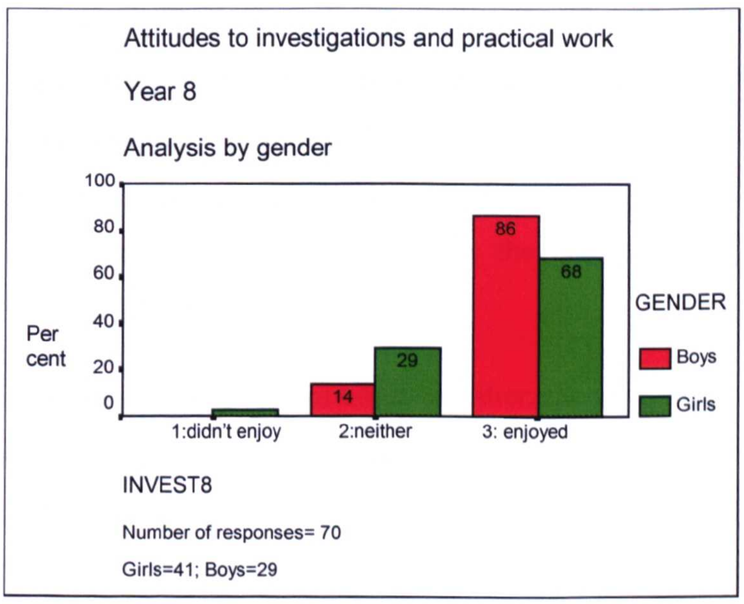
Ten girls, but no boys, made comments about science being "boring", most of them giving little further explanation on the matter. One boy (OLI12), however, linked his boredom to doing experiments "you know the outcome of".

There was no significant difference *(t=-1.543, df=143, p=0.125)* between the mean attitude scores to investigations *(2.54, SD 0.61)* for the cohort pupils *(n=69)* and that *(2.68, SD 0.55)* for the non-cohort pupils *(n=76)*; nor were there any significant differences between the cohort and non-cohort groups regarding the boys' and girls' mean attitude scores to investigations (see Appendix 6.3).

6.7.5 Year 8

In Year 8 the pupils were asked (Appendix 4.4, Question 8) to score, on a 3-point scale, how much they enjoyed investigations/practical work.

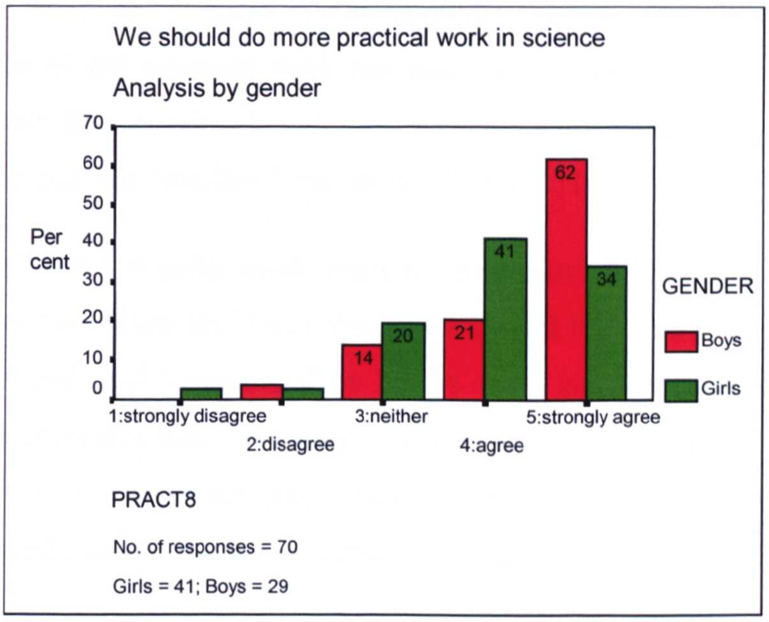
Fig.6.21: Attitudes towards investigations: Year 8



Practical work continued to be popular with the pupils, particularly with the boys (86% of whom recorded positive scores compared with 68% of the girls). The cohort mean score was *2.74, SD 0.47.* There was no significant difference *(t=1.806, df=68, p=0.075)* between the boys' mean score *(2.86, SD 0.35, n=29)* and that of the girls *(2.66, SD 0.53, n=41)*.

The pupils' comments in Years 5 to 7 about practical work prompted the inclusion in the Year 8 questionnaire of the statement: " We should do more practical work in science" and the pupils were asked (Appendix 4.4, Question 4.2) to record, on a 5-point scale, their views on this statement.

Fig. 6.22: Responses to 'We should do more practical work in science': Year 8



The mean attitude score for the cohort *(n=70)* was *4.19, SD 0.92.* As in earlier years, a particularly high percentage (62%) of the boys' demonstrated strong feelings about the inclusion of more practical work in science lessons - almost twice the percentage of boys, compared with the girls, strongly agreeing with the statement: "we should do more practical work in science". The modal score for the boys was 5 ("strongly agree") compared with 4 ("agree") for the girls.

When the positive scores of 4 and 5 were taken together, the percentage of positive scores amongst the boys (83%) was higher than that for the girls (75%). There was no significant difference *(t= 1.768, df=68, p=0.081)* between the mean scores for the boys and that for the girls *(4.41, SD 0.87, n=29* and *4.02, SD 0.94, n=41* respectively).

In an attempt to elicit more information from the Year 8 pupils about their attitudes to science lessons, they were asked (Appendix 4.4, Question 6) to give three things which they liked, and three things which they disliked, about science lessons. There were 151 positive comments, the vast majority of which referred to "experiments" or "practical", the 'Bunsen burner' receiving relatively few citations (by 5 boys and 1 girl) compared with Year 7. Two pupils were critical of the teacher-led demonstrations: "He does all the practicals hiself" (UNW29, a girl) and "Mr. X doing all the experiments" (UNW11, a boy).

Laboratory stools also met with criticism by 1 boy: e.g. "uncomfortable stools" (XLD16) and 3 girls: "sitting on stools" (UNW07, XLD04) or "can be annoying – the seat" (OLI02). Concerning the laboratory environment itself, one boy (XLI17) disliked "the room" and a girl (OLU09) particularly disliked "the smell from the cafet(e)ria" which was in close proximity to the laboratory in question. On a positive note, one boy (XLI23) liked science not only because of the practical work but because "we can talk to each other". This relaxed atmosphere also appealed to two girls who "liked the freedom in (science) lessons" (OLN04) and the fact that "you don't just sit there" (OLN11).

Several pupils (5 boys, 6 girls) made positive comments about "learning new things" (OLI05, a boy) or "you learn about why things work " (OLI02, a girl). "Videos" were cited by 6 boys and 4 girls and "computers" by 2 boys and 1 girl (although it was not clear in what context the computer was being used as part of a science lesson). The opportunity to work collaboratively in groups was mentioned by 4 girls (no boys) one of whom (OLU09) particularly enjoyed "being with friends from other classes".

Two girls with academic inclinations reported that they actually liked the "science *tests*" (UNW06) and "quizzes" (UNW15). The negative comments included the now familiar "too much writing" (18 boys, 20 girls) or "copying" from books or the board (5 boys, 4 girls). Three boys and 2 girls didn't like reading and 3 boys and 6 girls didn't like "drawing" or "graphs". Repetition attracted negative comments from 2 boys and "the teacher". Negative comments on the degree of difficulty were made by 1 boy and 2 girls; 5 girls (but no boys) didn't like the "tests" (at the end of each module).

6.7.6 Year 9

The additional questionnaire administered in Year 9, asked the pupils (Appendix 4.5, Question 3(g) and 3(h)) to identify those modules which they thought had too much practical work, and those which didn't have enough practical work: multiple responses were permitted in both cases; the data are summarized in Figs. 6.23 and 6.24.

There was some suggestion that although the girls thought that the chemistry modules contained too much practical work, both boys and girls thought that the biology modules did not have enough practical work (see also Appendix 6.9).

Fig. 6.23: Modules with too much practical work: Year 9

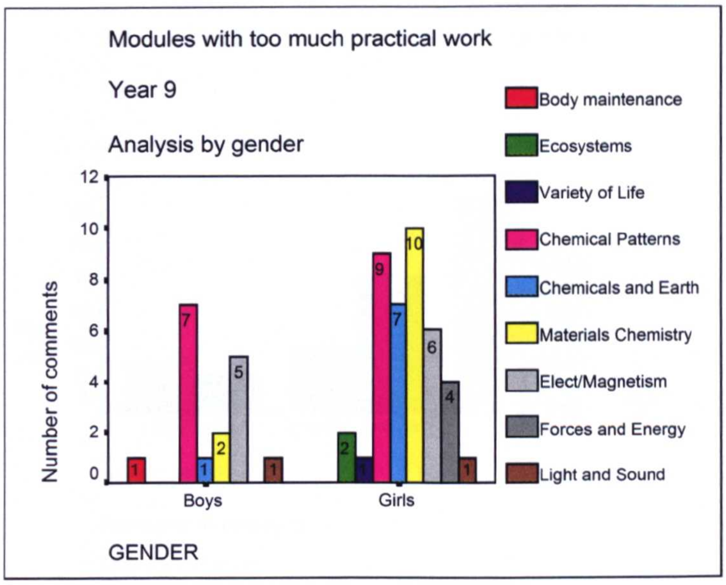
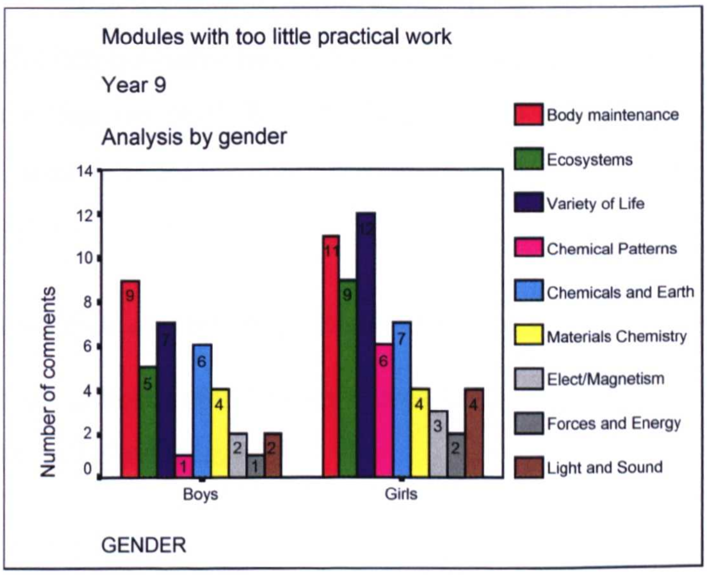
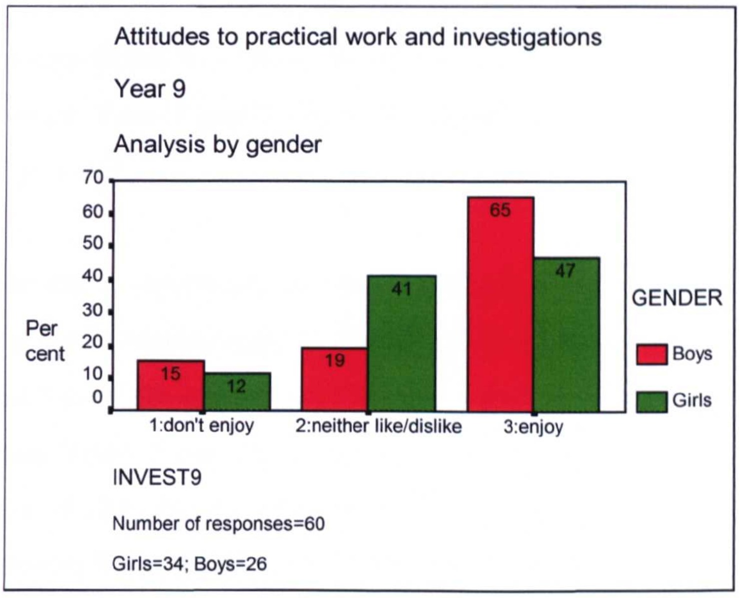


Fig. 6.24: Modules with too little practical work: Year 9



The pupils were also asked to record on a 3-point scale their attitudes to investigations/practical work (see Fig.6.25).

Fig. 6.25: Attitudes to investigation and practical work: Year 9

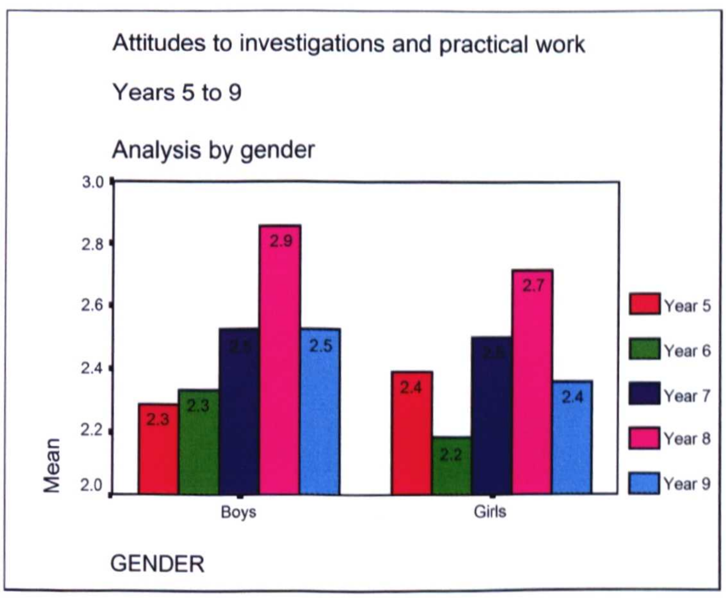


Not all the cohort pupils completed this additional questionnaire and the number of pupils submitting responses to this question dropped to 60. Although 65% of the boys (compared with 47% of the girls) demonstrated positive attitudes to practicals and investigations, there was no significant difference *($t=0.781$, $df=58$, $p=0.438$)* between the boys' *($n=26$)* and girls' *($n=34$)* mean attitude score towards investigations in Year 9 *(2.50, SD 0.76* and *2.35, SD 0.69* respectively).

6.7.7 Attitudes to practicals and investigations: Years 5 to 9

An examination of the cohort pupils' mean scores for practicals/investigations over the 5 year period is presented below (Fig. 6.26).

Fig. 6.26: Attitudes to investigations and practical work: Years 5 to 9



For the boys, there were no significant differences between the annual mean attitude scores for investigations (Years 5/6, 6/7 and 7/8) but the fall in mean attitude scores between Years 8 and 9 was significant *($t=-2.619$, $df=24$, $p=0.015$)*. For the girls, the drop in mean attitude scores between Years 8 and 9 was highly significant *($t=-2.876$, $df=39$, $p=0.006$)*.

For the girls, there was a significant *($p<0.05$)* improvement in attitudes between Year 6 (when the girls showed significantly more negative attitudes than the boys towards investigations) and Year 7 (at which point the boys' and girls' mean scores were virtually identical). Between Years 7 and 8 the increase in scores was not statistically significant *($t=-1.554$, $df=40$, $p=0.128$)* but, as with the boys, there was also a significant fall in mean attitude scores between Years 8 and 9 *($t=-2.505$, $df=34$, $p=0.017$)*.

This Chapter has focussed on pupils' attitudes to various "in-school" factors over the four years[5] of the study. In Chapter 7 the data on pupils' attitudes to other areas of the school curriculum are discussed; particular emphasis is placed on the qualitative data derived from the pupils' responses in Years 5 and 6.

[5] in some instances data for 5 years were available

Chapter Six: "In-school" factors: other aspects of science lessons

6.8 Summary

Chapter 6 examined some of the other "in-school" factors which might be linked with pupils' attitudes to science.

There was no significant difference between the Year 6 boys' and girls' scores on the question of difficulty although, for a few pupils, the lack of challenge seemed to attract comments. Pre-transfer, several of the pupils had expected secondary science lessons to be 'harder' but this did not seem to be a cause for concern for the vast majority of pupils. In Year 7 there were very few comments on the difficulty of science and these were all made by girls. By Year 8, a higher percentage of boys than girls disagreed with the statement: "Science is difficult to understand", but no significant gender difference was detected in the mean scores.

Only a very few pupils made comments which linked lack of understanding to the perceived difficulty of the subject. In Year 9 there was a suggestion that the Chemical Patterns module was the most difficult for both girls and boys to understand and the physics modules were perceived as difficult by a greater percentage of girls than boys.

In the secondary phase, the pupils were asked about their perceived performance in science. In Year 7 there was no significant gender difference in the pupils' mean scores but the boys had a higher mean score than the girls; by Year 8 the difference in scores was statistically significant.

In each of the Years 6 to 9 the pupils were asked how their interest in science lessons had compared with the previous year. There was no significant gender difference in the scores for interest in Year 7 compared with Year 6 but, by Year 8, the percentage of boys who thought that science was more interesting than in Year 7 was more than twice that of the girls and there was a significant difference between the boys' and girls' mean scores. This gender difference was also apparent in Year 9.

However, when asked for agreement/ disagreement with the statement "Science is interesting", there appeared to be a significant gender difference, in favour of the girls, in the responses. By Year 9, the girls found the biology modules most interesting whilst the boys demonstrated a distinct lack of enthusiasm for the 'ecosystems' module; at this point the girls held more negative attitudes than the boys to the physical science modules.

Both boys and girls demonstrated an increasing interest in science lessons on transfer to secondary school and a fall, particularly by the girls, between Years 7 and 8. For the Year 9 boys there was little change in their interest from Year 8 but the girls' attitudes showed some improvement.

Several negative comments were made by the secondary pupils about their relationships with their science teacher(s); in both years, a greater percentage of boys than girls recorded positive scores for their relationships.

Even by Year 6 comments were being made about repetition of content and similar comments were made in Year 7. In Year 8 it seemed that the boys were more prepared than the girls to express an opinion but the data should be interpreted with caution.

Negative comments on the amount of writing and note-taking involved in science were mainly offered by the boys but their comments were often related to the displacement of the preferred practical activities by the writing tasks. In Year 8, the majority of both boys and girls agreed that science involved a lot of writing; there was no obvious gender difference in the attitudes.

Investigations and practical work were popular in the primary school particularly with the boys and the same pattern continued into the secondary phase. Although the data derived from the additional questionnaire in Year 9 only covered 60 pupils in the cohort, for these pupils there was a statistically significant drop between Year 8 and Year 9 in the mean attitude scores to investigations for both the boys and the girls.

Chapter Seven: "In-school" factors: popularity of school science compared with other subject areas

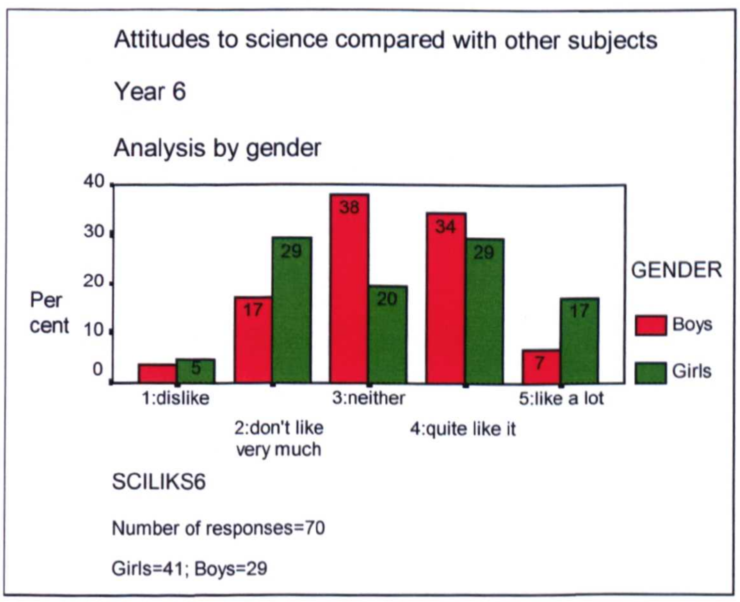
Introduction

Some of the "in-school" factors which might influence pupils' attitudes to school-based science were discussed in Chapters 5 and 6. This Chapter examines pupils' attitudes to science lessons compared with those towards other school subjects (particularly the humanities in Years 5 and 6). The rationale for inclusion in the study was to see whether the pupils' comments on the non-science subjects might provide any indicators as to how science topics might be better, or more interestingly, presented. From Year 6 onwards, the cohort pupils' quantitative and qualitative data on their favourite subject areas are discussed.

7.1 Attitudes to science compared with other subject areas: Year 6

In Year 5 the pupils did not necessarily see a clear distinction between their topic work in 'science' and in the 'humanities', and so only in Year 6 were the pupils asked (Appendix 4.2, Question 4) to record, on a 5-point scale, how they felt about (school) science compared with other subjects.

Fig. 7.1: Attitudes to science compared with other subjects: Year 6



The mean scores[1] *(3.24)* of both the boys and the girls were the same *(SD 0.95, n=29* and *SD 1.20, n=41* respectively); there was little difference between the percentages of boys' (41%) and girls (46%) awarding positive scores. However, it appeared that the girls were more extreme in their views than the boys – only 20% of them, compared with 38% of the boys, recorded a 'no preference' score.

Seventeen per cent of the girls, compared with only 7% of the boys, recorded that they 'liked (science) a lot' compared with other subject areas, but 29% of the girls, compared with 17% of the boys, 'didn't like it very much'. At the top end of the positive scale (score '5'), the gender bias in favour of the girls was reflected by the data from the whole year group[2].

Examination of the pupils' qualitative comments gave relatively little explanation for their decisions. Comments made by those recording the most positive scores expressed an enthusiasm for "finding out" about things (UNW21 and XLD03, both girls, and OLU8, a boy); several liked it "because it was interesting" (UNW14 and XLD01, both girls). Only one pupil specifically mentioned the practical aspects: "I like it because I can test things" (XLI04, a girl).

Only two of the pupils who "quite liked" science commented positively on the practical work: "You do lots of exsperements" (XLI13, a boy) and "because I like doing experiments" (XLI20, a girl). One boy (OLU11) commented that he liked science "because he liked electricity" but, again, little additional detail was provided. One girl (XLI07) who declared that she "quite liked science", expanded: "Cause you can do something like cut the worm in half" (though it was relatively unlikely to have been a Year 6 activity).

Only two of the "neither like nor dislike" comments were specific enough to reveal any underlying reasons for this neutral score. A boy (XLD14) commented: "Because you have to write to much (and I don't like it)" and one girl (OLN07) liked the experiments but didn't like "sorting things into sets". Amongst those pupils who recorded negative attitudes, one boy (UNW04) commented that he didn't like it very much "because you

[1] The mean attitude score for the cohort was *3.24, SD 1.10, n=71*; this was very close to that recorded *(3.31, SD 1.08, n=101)* for the whole year before attrition.

[2] Thirteen (25%) of the girls *(n=52)* recorded 'don't like it very much' scores compared with only 7 (14.3 %) of the boys.

have to do a lot of ritting (writing)"; three pupils (all girls) linked their dislike of science (lowest score of '1') with its perceived difficulty[3] e.g. "because it is hard" (XLD11).

7.2 Science and favourite subject area

7.2.1 Year 5

From Year 5 onwards, the pupils were asked to state their favourite subject areas and, from Years 6 to 8, to give reasons for their choices. In order to identify whether 'science' was already attracting positive attitudes in Year 5, the pupils were asked to name the school subjects, or activities, which they most enjoyed and it was obvious from the responses that the majority of the pupils found it difficult to select just one or two 'favourites' from their multiple activities.

The questionnaire (see Appendix 4.2) did not attempt to exclude physical activities[4] from the list of choices and a wide range of sports including cricket, hockey, baseball, football, American football, swimming, rounders and 'P.E'. were cited. This rough guide to the range, and relative popularity, of the school activities available to the Year 5 pupils does not merit statistical interpretation but when the distribution of 'favourites' for the cohort group was compared with that available for the complete year group, there was good agreement (see Figs. 7.2 and 7.3).

[3] See Chapter 6.1 for the responses on the perceived difficulty of science (Appendix 4.2).

[4] The pupils were not asked to place their 'favourites' in rank order of preference; if 'P.E.' was the first named activity the next 'academic' subject listed was taken as the pupils' preferred subject area.

Fig.7.2: Subject preferences
Year 5 (full year)

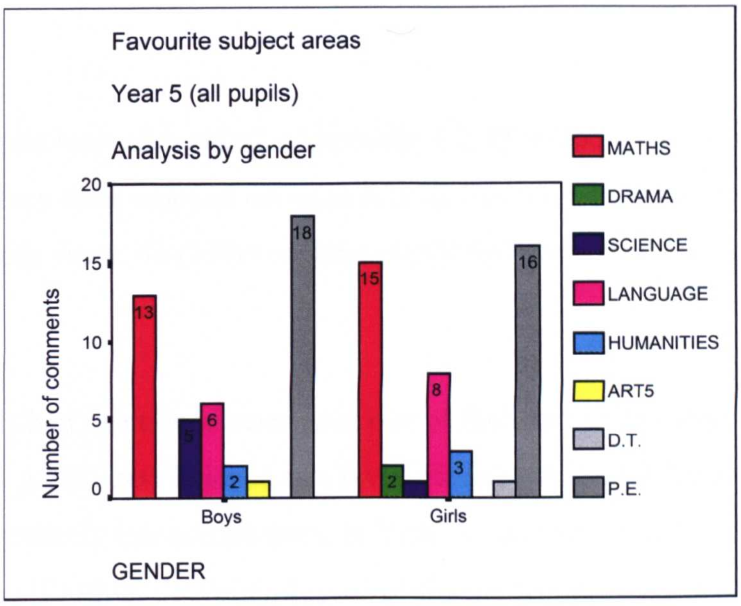
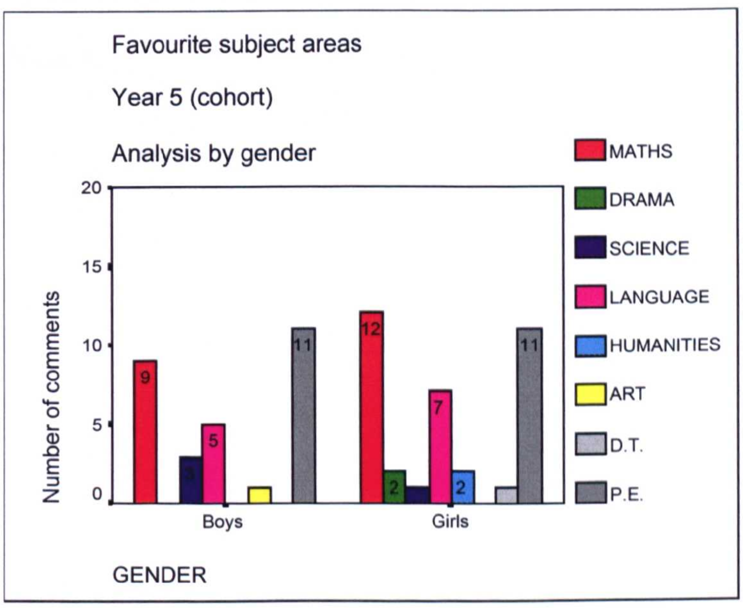


Fig.7.3: Subject preferences
Year 5 (cohort)



In the cohort group (30 boys, 41 girls), there were nine citations of 'science'[5] as a favourite subject area; a list of responses from the full year group is given in Appendix 7.1.

7.2.2 Year 6

In Year 6, the pupils were also asked (Appendix 4.2, Question 2) to name the subjects, or activities, which they most enjoyed doing in school. Seventy-six of the pupils responded to this question in both years; 43 (57%) of these pupils had some degree of consistency about their answers.

Whereas 15 pupils had mentioned science as one of their favourite subjects in Year 5, only one pupil (XLI04, a girl) gave science as a favourite subject in *both* Years 5 and 6. This is not, however, an entirely fair comparison; in Year 5, 'science' was covered under various topic headings e.g. 'Earth in Space' and some of the pupils may have recorded their Year 5 'science' preferences under the more general area of 'topic' instead. By Year 6, the pupils' responses were almost all recorded as timetabled subjects but, in the few cases where this was not so, the subject area could be identified from the name of the topic e.g. 'beaches' (humanities) or 'living things' (science). Only 5 children, however, included science as a favourite topic in Year 6.

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[5] For the full year group, there were 84 written responses (45 boys; 39 girls) with 'science' attracting 15 citations (from 9 boys and 6 girls). Five of the citations (from 4 boys and 1 girl) placed science in first position, position, 4 citations (from 2 boys and 2 girls) placed it in second position and 6 citations (from 2 boys and 4 girls) placed science in third or lower position on the list.

Table 7.1: Pupils recording science as a favourite subject in Year 6: comparison with Year 5

Pupil code	**Favourite subject**	
	Year 5	**Year 6**
OLU03(boy)*	P.E., art, history	History and **science**
XLD01(girl)	maths	English, **science,** Maths
XLD05(girl	maths	maths, Sicer **(science?)**
XLI04(girl) *	maths,**science**,swimming, pe,games	**Science**
XLI15(girl) *	maths	**Science**
*** Answered "Yes" to "Might you like to be a scientist one day?"**		

(For comparison of hobbies and interests for these pupils see Table 8.1, Chapter 8)

7.3 The humanities and science: Years 5 and 6

In Years 5 and 6 an attempt was made to assess the pupils' attitudes to the humanities topics and, using the quantitative data, to compare (with respect to gender) the pupils' mean attitude scores to the humanities and the science topics studied over the two-year period.

In Year 5 the humanities work was distributed amongst four topics: Exploration (Schools OL and UN), The Tudors (School XL), Mapwork (Schools OL and XL) and Villages/towns (School UN) - each primary school therefore covered two humanities topics during the year. In Year 6, a different range of humanities topics was covered. These embraced topics from the traditional areas of 'geography' and 'history', the former covering a range of comparative studies between the Isle of Wight (School XL), Kenya and modern Greece (School OL), and Yenworthy and Newbury (School UN) and the local community. The 'historical' studies also differed from school to school: 'Castles and houses' (School XL), the Victorians and Ancient Greece (School OL) and the Tudors and the Greeks (School UN). Unlike the science modules there was no progression, or extension, of the previous year's topic, so comments about repetition would not be expected.

The mean attitude scores for each of these topics, analysed by gender, are given in Appendix 7.2 and the details of the qualitative comments are presented in Appendix 7.3.

7.3.1. Summary of Year 5 pupils' comments on the humanities topics (Appendix 7.3).

The **Exploration** topic received very positive responses from both boys and girls, these comments centred mainly on the modelling work (making Aztec houses) - a particularly high percentage of boys (45%) recorded the highest score of '5' for this topic.

The **Tudors** module (School XL only) was also very popular, particularly with the girls. Little detail was, however, provided in their comments - two of the girls favoured the topic because of the 'colouring and drawing' but there was surprisingly little comment about the traditional girls' interests in the clothes, fashion or food of the day. The boys gave much more specific comments about what fired their imaginations: executions, fire, plague, and battles. Both boys and girls also commented favourably on the inclusion, as part of the work on the topic, of a school trip to a Tudor Manor House.

The **Villages and Towns** topic (School UN only) was rather less popular than the two other topics, especially with the girls. As with the **Exploration** topic, the positive comments on the villages/towns topic linked the higher scores with practical tasks such as drawing, or making models of, houses. The negative comments, by both boys and girls, often cited 'too much writing' and several pupils commented that they disliked 'all the drawing'. Again it appeared that the positive attitudes to this humanities topic were stimulated by some interesting practical work; the writing, as in science lessons, seemed to be a negative point for both boys and girls.

Only pupils at Schools OL and XL studied the **Mapwork** topic. For the boys this was the least popular of the humanities topics but the girls' *(n=32)* mean score was very slightly higher than that of the 9 girls who studied the 'Villages and Towns' topic at School UN. The large number of pupils showing negative attitudes towards the mapwork topic rarely expanded their comments beyond 'boring' although, in a few cases, specific problems (e.g. the small print) were highlighted. The special skills involved in map-reading, including the search for co-ordinates, attracted positive comments from only 3 pupils (all boys).

7.3.2. Summary of Year 6 pupils' comments on the humanities topics (Appendix 7.3).

Year 6

Although there were differences between the three schools in the choice of the **different communities** which would form the basis of the study, both boys and girls (77% and 73% respectively) gave these topics very positive scores. A large number of pupils commented that they had found the topics 'interesting' or 'fun' but relatively few pupils expanded on their reasons. Not surprisingly, some of the attraction of the Isle of Wight study was the opportunity to go on a residential visit to the seaside. The very few negative comments (7 out of 61 responses) gave little explanation as to why the topic was regarded as 'boring' but two pupils reported that there was too much emphasis on reading and drawing.

The **Castles and houses** topic (School XL) was clearly a popular topic. The comments predominantly referred to the 'interest' factor and 'finding out' about things, particularly learning about the past. The artwork associated with the topic seemed popular although there were, perhaps inevitably, some dissentions.

The pupils from School XL had studied the Tudors during Year 5; in Year 6 only the pupils at School UN covered both the **Tudors and the ancient Greeks** and the top score ('5') was awarded to the topic by all 15 pupils. The girls at School UN showed more enthusiasm for the history topics in Year 6 than the (Year 5) girls at School XL. Detailed comparisons of the pupils' attitudes to this topic with the Year 5 'history' module are inappropriate because of the very small numbers involved, the different schools and the split in emphasis (between the Tudors and the Greeks) in Year 6. The positive comments in Year 6 mainly focussed on the practical aspects of making models of Tudor houses, the artwork and performing a play on a Tudor theme. The boys' positive comments focussed more on the play which they were asked to write and then perform.

The Victorians was only covered by the Year 6 class[6] in School UN. It was an extremely popular module but few clues (other than 'interesting' or 'very interesting') were given as to why the topic had attracted so many high scores. Three of the pupils made positive comments about the opportunity for 'learning' and one commented on the 'research' element. None of the respondents mentioned the writing, artwork or modelling content of this topic so it could be assumed that the style of presentation (through drama and re-enactment of a day in the life of a Victorian child) was sufficiently positive to provide a good stimulus for the children's engagement with the topic.

[6] 16 girls and 8 boys.

7.4 Mean attitude scores to humanities modules

As with the scores for the science modules, the mean humanities scores were obtained by averaging the pupils' scores for the four individual humanities modules studied in both Years 5 and 6 - see Appendix 7.2. In neither Year 5 nor Year 6 were there significant differences between the boys' *(n=30)* and girls' *(n=41)* mean attitude scores to the humanities (*t=0.612, df=69, p=0.543* and *t=-0.828, df=69, p=0.411* respectively).

For the cohort boys *(n=30)*, there was a highly significant difference *(t=-4.06, df=29, p=0.001)* between their mean attitude scores to the humanities topics in Years 5 and 6; three boys recorded a lower score in Year 6 compared with Year 5 and 20 boys recorded a higher score compared with Year 5. Seven of the boys recorded the same scores in both Years 5 and 6. Similarly, for the cohort girls *(n=41),* there was also a highly significant difference between their mean attitude scores to the humanities topics in Years 5 and 6 *(t=-6.11, df=40, p=0.001.* In Year 6, four girls recorded a lower score for the humanities compared with Year 5 but 30 girls recorded a higher score. Seven of the girls recorded no change in their scores for the humanities topics between Year 5 and Year 6.

7.5 Attitude scores to science topics and humanities topics: Years 5 and 6

The mean attitude scores for the humanities over the two-year period were compared with those for the science topics. The physical and biological science, and humanities, topics attracting the highest mean scores in Years 5[7] and 6[8] are presented in Appendix 7.4. These data must, however, be interpreted with caution – the curriculum coverage of biology in Year 5 lacked uniformity and so, for the topics covered, very small sample sizes were often involved. For the science topics, item analysis[9] showed that, in Years 5 and 6, a more reliable mean score for the pupils' attitudes would exclude the 'materials' score and an *adjusted* mean attitude score is quoted (see Chapter 5.3).

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[7] 'Space': physical sciences; various: biological sciences; 'The Tudors' : humanities.

[8] 'Electricity and magnetism' (physical sciences), 'Living things' (biological sciences -single topic), 'Tudors and Greeks' (humanities).

[9] Item analyses for the humanities topics were not appropriate - each of the three schools undertook different topics (particularly in Year 5).

7.5.1 Mean attitude scores for science and humanities topics: a comparison

7.5.1(i) <u>*Year 5*</u>

For the Year 5 cohort pupils *(n=71)*, there was a significant difference *(t=-3.592, df=70, p=0.001).* between the *adjusted* mean attitude score over all the science topics (*3.79, SD 0.84)* and the mean score for the humanities (*3.19, SD 1.09).* For 37 pupils, their science score was *higher* than their humanities score and for 29 pupils it was *lower;* in 5 cases there was no difference between the mean scores.

7.5.1 (ii) <u>*Year 6*</u>

For the Year 6 cohort pupils, the preferences were reversed and the difference between the *adjusted* mean science score *(3.23, SD 0.86)* and that for the humanities *(4.20, SD 0.70)* was highly significant *(t=7.802, df=70, p=0.001).* Sixty-three pupils recorded higher mean attitude scores for the humanities than for the sciences and, for only 6 pupils were the mean science scores greater than their mean humanities scores (in 2 cases they were the same). A similar pattern was shown by the full year group.

These data suggest that the pupils' preferences for science indicated in Year 5 are reversed during the last year of primary school and a clear preference for the humanities begins to show by the end of Year 6.

7.5.2 Mean attitude scores for science and humanities topics: gender differences

7.5.2.(i)<u>*Boys*</u>

For the cohort boys *(n=30)* in Year 5, the difference between the mean humanities score *(3.28, SD 0.98)* and the *adjusted* mean score for all the science topics *(3.68, SD 0.69)* was not significant *(t=-1.374, df=29, p=0.180).* For 14 boys, the mean humanities score was higher than the mean science score, for 14 pupils the preferences were reversed and, for 2 boys, the scores were the same.

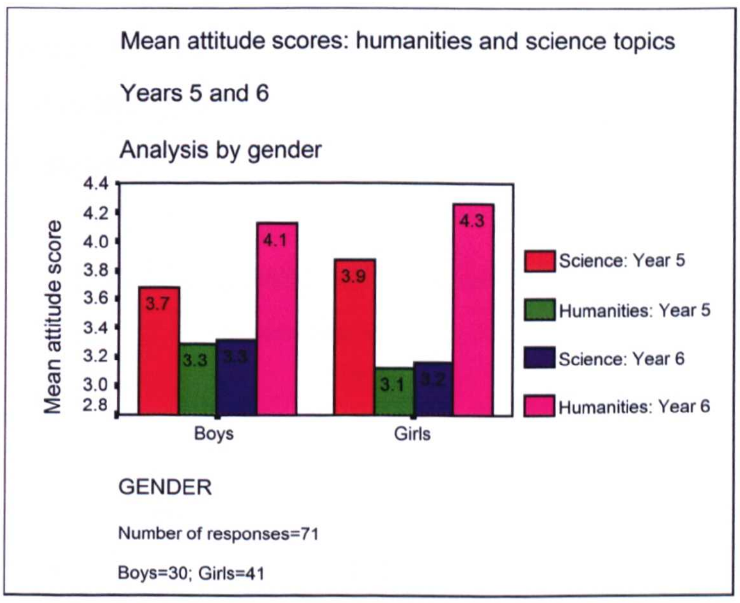
In Year 6, the difference between the boys' mean attitude score for the humanities topics *(4.12, SD 0.85)* and the *adjusted* mean score for all the science topics *(3.32, SD 0.94)* was significant (*t=3.602, df=29, p=0.001).* For 25 boys (83% of the boys), the mean humanities score was higher than the mean science score; 4 boys (13%) had mean science scores greater than the mean humanities score and, in one case, there was no difference - this was in good agreement with the data obtained from the 50 boys in the complete year group.

7.5.2 (ii) Girls

For the girls *(n=41)* in the Year 5 cohort, the difference between the mean attitude score *(3.12, SD 1.18)* to the humanities topics and the *adjusted* mean attitude score *(3.88, SD 0.86)* to all the science topics was significant *(t=-3.759, df=40, p=0.001)*. For 15 girls (37% of the girls), the humanities score was higher than the mean science score, for 23 girls (58.5%) the preferences were reversed and, for 3 girls, there was no difference.

The difference between the Year 6 cohort girls' mean score for the humanities *(4.26, SD 0.56)* and the *adjusted* mean science score *(3.16, SD 0.80)* was highly significant *(t= 7.772, df=40, p=0.001)*. Thirty-eight girls (93% of the girls), recorded a mean humanities score which was higher than the *adjusted* mean science score and, for only 2 girls (5%), were the preferences reversed. One girl had the same mean scores for both categories[10]. For both boys and girls there was a highly significant difference between the mean attitude scores for the science and humanities topics at the end of Year 6, see Fig. 7.4.

Fig. 7.4: Comparison of attitude scores: humanities and sciences Years 5 and 6



Both the boys' and girls' mean attitude scores to the humanities topics increased significantly *(t=-4.059, df=29, p=0.001* and *t=-6.110, df=40, p=0.001* respectively) between Years 5 and 6; twenty (66.7%) of the boys, and 30 (73.2 %) of the girls recording higher mean attitude scores to the humanities in Year 6 compared with Year 5.

[10] This pattern was reflected by that of the girls *(n=52)* in the complete year group.

Although, for the boys, there was no significant difference between the mean attitude scores to the humanities topics and to the science topics in Year 5, by the end of Year 6 a significant difference *($t= 3.602$, $df=29$, $p=0.001$)* in favour of the humanities was recorded with 25 (83.3%) of the boys preferring the humanities topics to the science ones. The girls, who had demonstrated a significant preference *($p<0.01$)* for the science topics in Year 5 had reversed their preferences by the end of Year 6 and, as with the boys, there was a highly significant difference *($t=-3.759$, $df=40$, $p=0.001$)* between the mean humanities score and the *adjusted* mean science score.

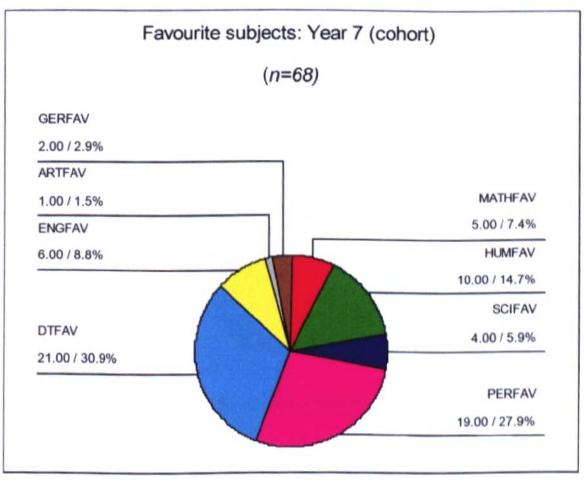
7.6 Favourite subjects in the secondary phase

By Year 7 the pupils were exposed to a more closely defined secondary school curriculum and this enabled some comparisons to be made between specific subjects areas, rather than between groups of modules.

7.6.1 Year 7

The Year 7 questionnaire (Appendix 4.3, Question 6) asked the pupils to state their favourite subject (other than P.E.) and to explain the reasons for their choice (Fig.7.5). Taken together, Design and Technology (D.T.) and the Performing Arts accounted for nearly 60% of the responses; science was regarded as the favourite subject by only four pupils (6% of the responses).

Fig. 7.5: Favourite subjects: Year 7 (cohort)



7.6.1 (i) Gender differences

The data were examined for any gender differences between the boys' and girls' choices, see Figs. 7.6 and 7.7.

Fig. 7.6: Boys' favourite subjects

Year 7 (cohort)

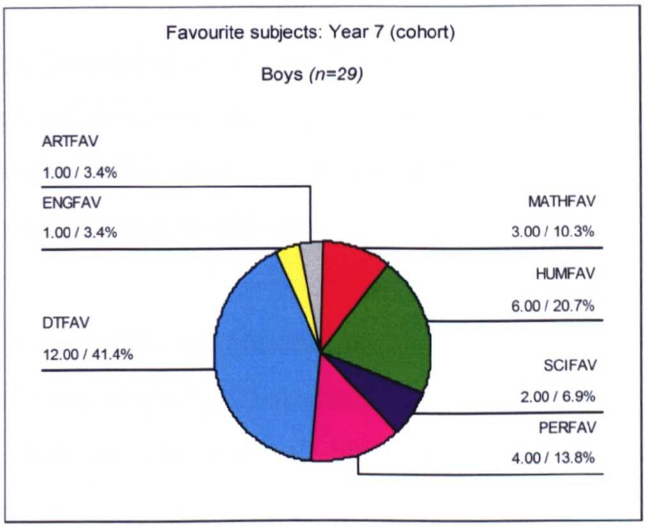
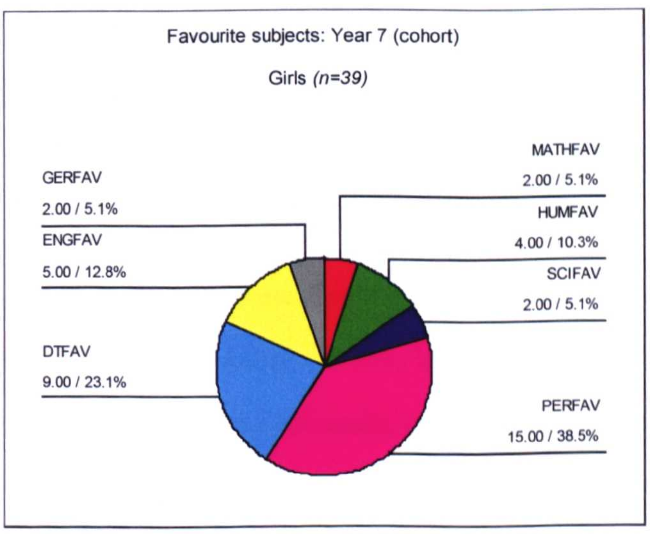


Fig. 7.7: Girls' favourite subjects

Year 7 (cohort)



The gender analysis of the cohort data showed the clear preferences of the girls, compared with those of the boys, for the performing arts and for English. Twice the percentage of boys (20.7% compared with 10.3% of the girls) recorded humanities as their favourite subject area; design and technology was much more popular with the boys than with the girls, 41.4% of the boys recording it as their favourite subject compared with 23.1% of girls. Although both the sample sizes are quite small, it should perhaps be noted that none of the boys regarded modern languages as a favourite subject and, perhaps surprisingly, no girls (and only one boy) recorded art as their favourite subject. The majority of the Year 7 pupils' comments were relatively uninformative; their choice of 'favourite' subject was, in most cases, based on the 'enjoyment' or 'fun' factor and, in only a few cases, was the actual content or learning process mentioned.

One girl (OLN11) liked drama (performing arts) best because "You can be loud and express your feelings"; one boy (XLD16) admitted that his choice was based on the fact that it was "easy" and had the "best teacher". Sixteen of the 19 comments about design and technology referred to an enthusiasm for the construction element involved e.g.
"because we can make things (and) use machines" (XLI23, a boy) and "because its fun and I like making things" (OLU09, a girl).

The curriculum content was mentioned by two girls who regarded English as their favourite subject: "I like writing stories and acting" (OLN04); "because we are doing a play" (XLI12). Another girl (OLI03) linked her choice of English as her favourite subject with her performance: "because I am good at it and I like the teacher". Two other pupils, however, expressed opposing views on the amount of work involved:

XLD24 (boy)	"because there is lots to do"
XLD09 (girl)	"because we hardly have to do anything"

Six of the 10 comments by pupils whose favourite subject area was humanities, mentioned their liking for the teacher as being an important reason for their choice: "because the teacher is nice" (UNW09, a boy); "because I like the teacher" (UNW10, a girl). One girl (OLI06) found humanities "fun and interesting" and commented that she "liked working with other people". Humanities appeared to be the only area where the pupils' positive relationship with the teacher was regularly cited as the main reason for their choice of favourite subject.

Although one girl (OLI01) preferred mathematics "cos it's over the quickest", mathematics was the only curriculum area where there was a strong link in the qualitative responses between the pupil's perceived performance in the subject and the choice of mathematics as their favourite subject e.g. "because I am very good at it and enjoy it" (OLI05, a boy). One of the girls (OLU12) enjoyed the 'challenge' of mathematics.

Only four cohort pupils, two boys and two girls, had given science as their favourite subject and the number of responses was, therefore, far too small to identify any overall pattern in the reasons for their selection. Two of the pupils commented on the 'excitement'/ 'fun' factor e.g. "because theres lots of fun experiments" (XLI03, a boy) and another boy (OLU06) liked it "because we do basic skills" (learning the correct use of the Bunsen burner etc.); a girl (XLI11) commented simply: "because the teacher is nice".

7.6.1 (ii) Cohort and non-cohort pupils: a comparison

Data were available from 73 other pupils who had joined the participating secondary school from other (non-participating) primary schools; these non-cohort pupils' responses are shown, together with those of the cohort, in Figs. 7.8 and 7.9

Fig. 7.8: Favourite subjects: Year 7(cohort)

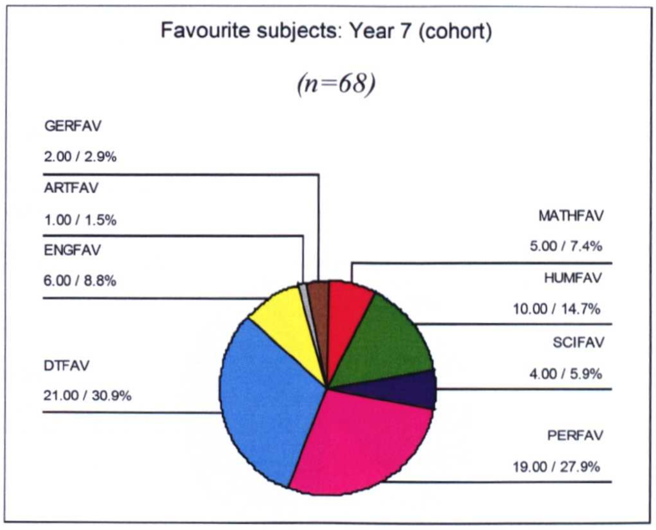
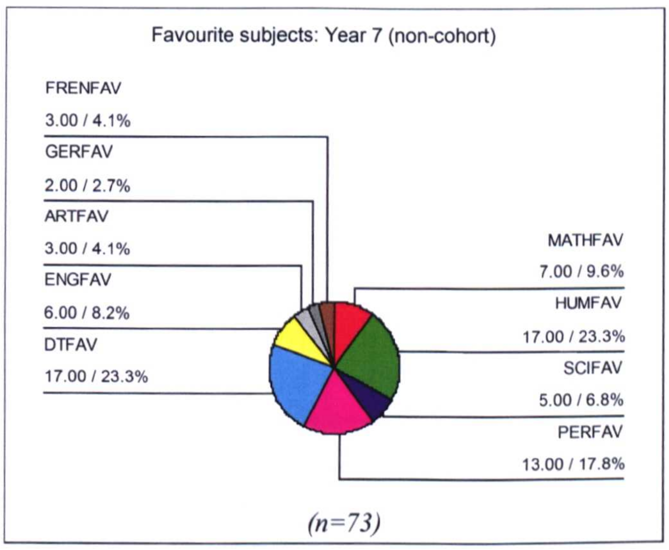


Fig. 7.9: Favourite subjects: Year 7(non-cohort)



Because of the small number of pupils involved, little statistical significance can be attached to the differences between the percentages of cohort and non-cohort pupils preferring art and modern languages. However, the greater enthusiasm by the cohort pupils (compared with their non-cohort colleagues) for the performing arts, at the possible expense of the humanities, is interesting. Possibly, the facilities for drama and music at the 'new' school were more familiar to the cohort pupils (who came entirely from the three local primary schools) and this earlier familiarity may have given them more confidence and enthusiasm to perform).

Fig. 7.10: Favourite subjects: Year 7 cohort boys (n=29)

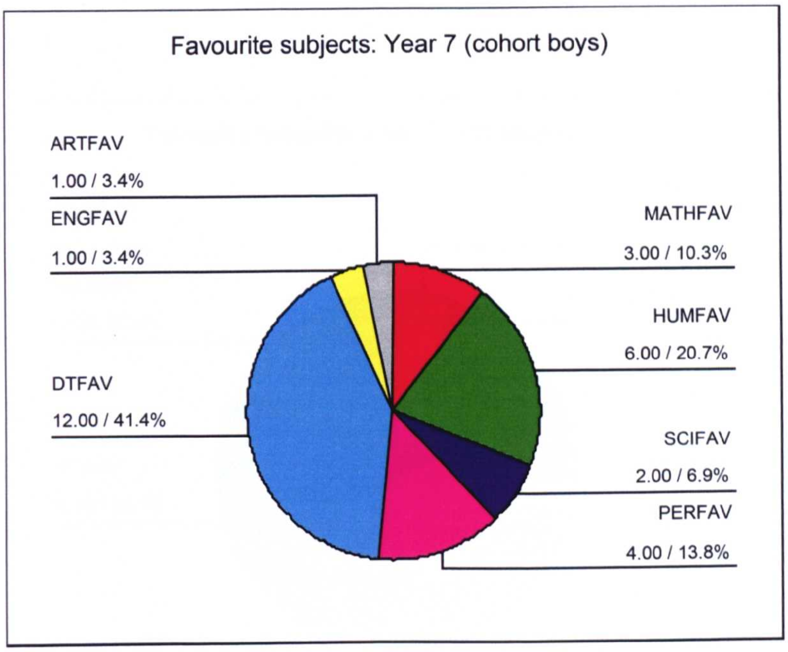


Fig. 7.11: Favourite subjects: Year 7 non-cohort boys (n=29)

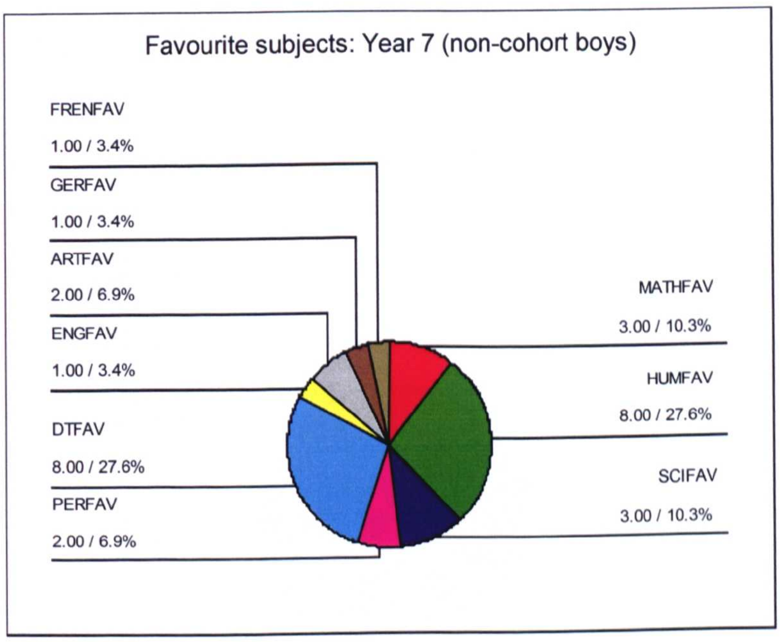


Fig.7.12: Favourite subjects in Year 7 cohort girls (n=39)

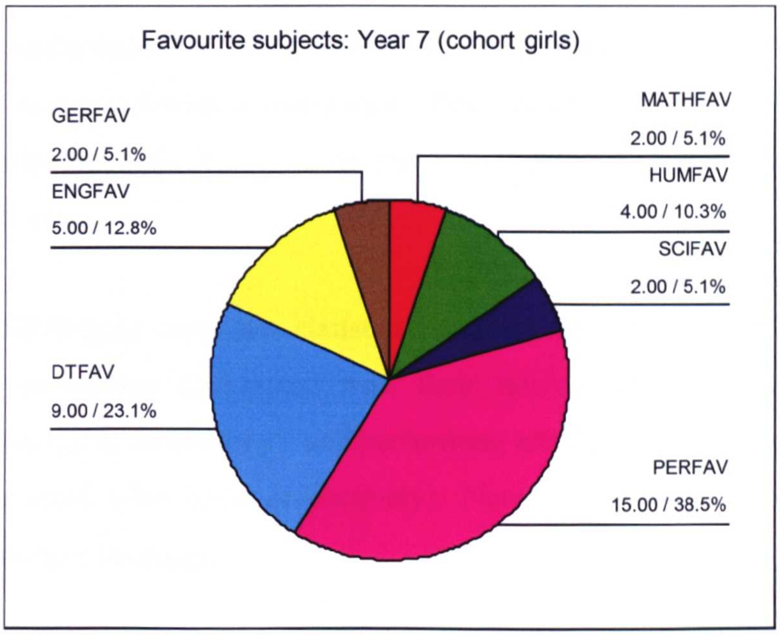
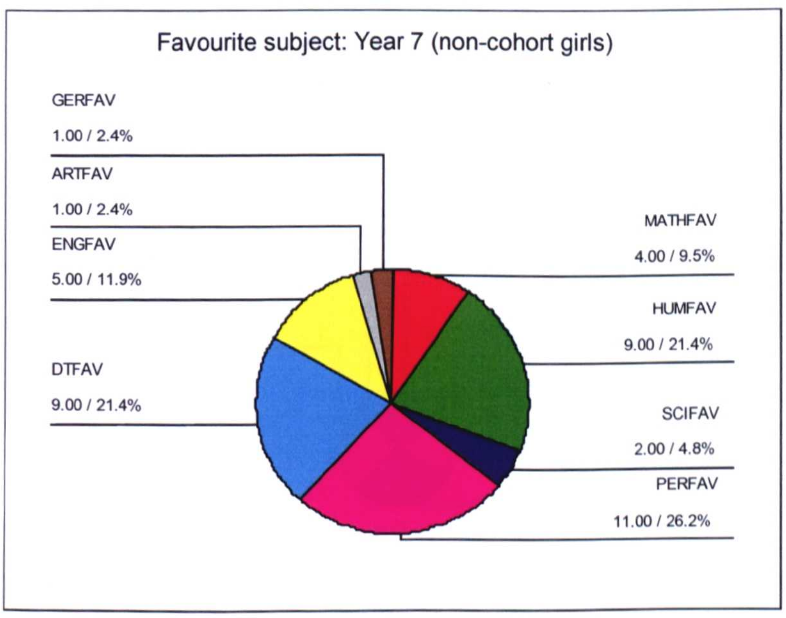


Fig. 7.13: Favourite subjects in Year 7 non-cohort girls (n=42)



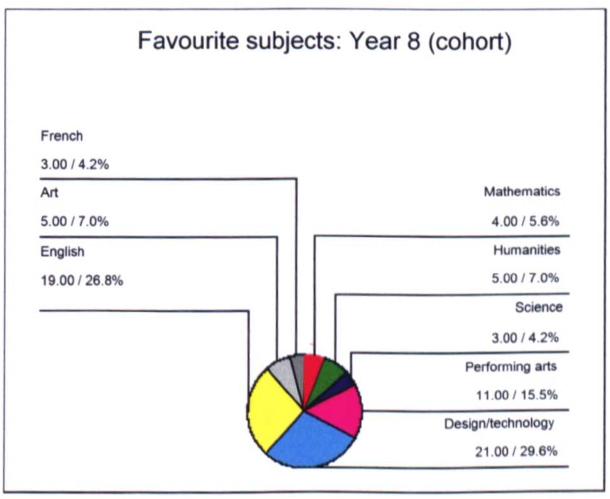
For the more popular subject areas, the gender bias (towards the girls) was particularly noticeable in the performing arts and English. Out of the 19 cohort pupils who recorded performing arts as their favourite subject area, 15 were girls (38.5% of the girls in the cohort) and 4 were boys (13.8% of the boys in the cohort). The cohort girls demonstrated an even greater enthusiasm for the performing arts than their non-cohort colleagues. This may have been associated with a swing away from the humanities - only 10.3% of the cohort girls, compared with 21.4% of the non-cohort girls, recorded humanities as their favourite subject area.

Although the differences were not statistically significant, the cohort boys showed a slightly higher percentage (compared with their non-cohort colleagues) of recorded preferences for design & technology[11] and performing arts[12] (41.4% compared with 27.6% and 13.8% compared with 6.9% respectively). None of the cohort boys expressed a preference for modern languages.

7.6.2 Year 8

As in previous years, the Year 8 pupils were asked (Appendix 4.4, Question 1) to name their favourite subject area.

Fig.7.14: Favourite subjects in Year 8 (n=71)



The number of pupils who recorded science, or mathematics, as their favourite subject was one fewer in each case compared with the previous year. Humanities also appeared to have declined in popularity (10 pupils recorded it as their favourite subject in Year 7). There was a very slight increase (from a solitary pupil in Year 7 to 5 pupils in Year 8) in the number of pupils recording art as their favourite subject; the popularity of design and technology remained approximately constant. The considerable reduction (to almost half)

[11] *(t=0.989, df= 61, p=0.327)*
[12] *(t=1.152, df=61, p=0.254)*

in the number of pupils recording performing arts as their favourite subject may, at least in part, be balanced by the increased enthusiasm (from 6 pupils in 1997 to 19 pupils in 1998) for English. It was possible that more performance opportunities were now being incorporated into English lessons at the expense of the timetabled hours for performing arts. Further discussion within the school, however, seemed to suggest that the two changes were not directly linked – the self-consciousness of young adolescents (particularly boys) appeared to be the explanation for the drift away from the performing arts, whereas the English curriculum (and the various styles in which it was delivered) seemed to be stimulating more interest, to both boys and girls, than in Year 7.

> "We learn about the history of Shakespeare in poetry and (we) are going to the Globe theatre and I enjoy the things we do in English."
>
> **(XLD17, a boy)**

The responses for 'favourite subject' on twenty transcripts of the tape-recordings given by the cohort pupils were compared with the responses given by the same pupils on the written questionnaires. Fifteen of the verbal responses were consistent with the pupils' written responses.

7.6.3 Gender differences

The data, including the tape-recordings, were examined for any gender differences between the boys' and girls' choices. There appeared to be very little real difference between the boys' and the girls' distribution of choices (see Figs. 7.15 and 7.16) except in the performing arts where, again, the gender bias towards the girls demonstrated in Year 7 was maintained.

Fig. 7.15: Favourite subjects: Year 8 cohort boys

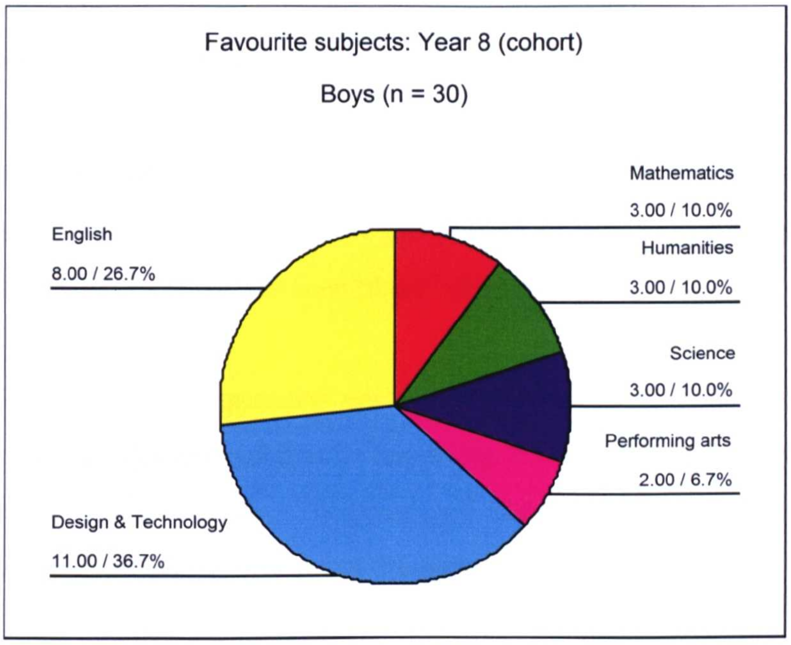
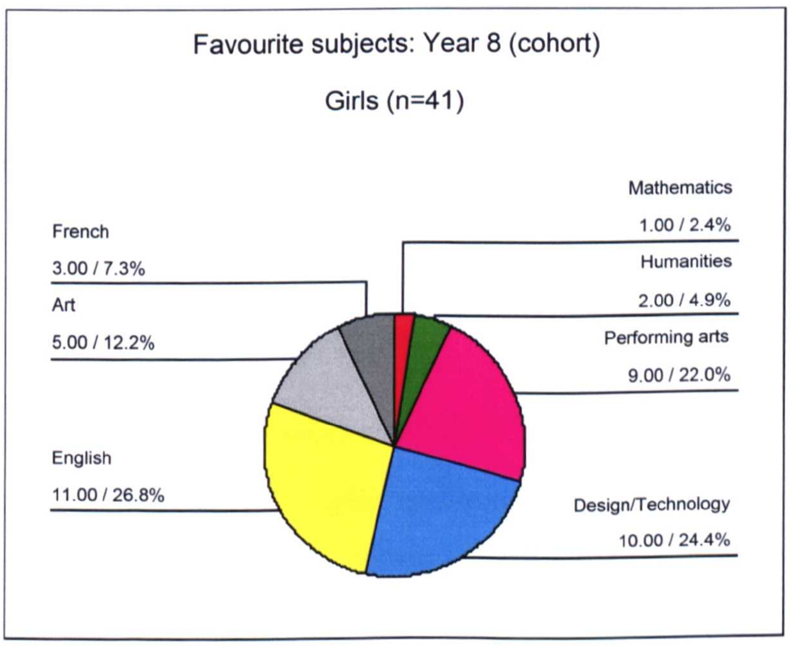


Fig. 7.16: Favourite subjects: Year 8 cohort girls



A tentative explanation for the drop in interest (particularly by the boys) in the performing arts, has been suggested earlier in this section; some of the girls who were still enthusiastic performers commented specifically on the opportunity for self- expression: "you get to express your feelings and emotions and that's important" (UNW06). Three of the girls specifically mentioned that their positive attitudes towards the performing arts were related to opportunities for group activities e.g. we get to work in groups and perform our plays to the class, we usually get to make our own plays" (OLN07).

Increasing self-consciousness appeared not to have affected the two boys who recorded performing arts as their favourite subject. One of the boys (UNW01) explained that one of the reasons for his choice was that "it gives you confidence in yourself; the other boy (XLI19) simply "enjoyed acting in front of the class".

Nineteen pupils (8 boys and 11 girls) regarded English as their favourite subject and six of these pupils (3 boys, 3 girls) related their positive attitude to the subject to the teacher's personality or teaching style: "cause we've got a cool and funny teacher" (XLD12, boy); "the teachers funny and she is like one of us" (XLI15, girl). More specifically, one of the pupils (OLI03) mentioned that she enjoyed the "freedom to produce your work how you want to some extent".

As in Year 7, Design and Technology was regarded as 'favourite' because of the creative aspects and, in some cases, the minimal amount of writing involved e.g. "you do practical every lesson and you get to make things and take them home" (XLD21, a boy); "I like designing and making things" (OLN04, a girl).

7.7 Pupils' re-call of Year 7 preferences

In an attempt to check the validity of pupils' preferences, the pupils were asked (Appendix 4.4, Question 3) whether their favourite subject in Year 8 was the same as that recorded in Year 7. Exactly half of the (66) pupils responding to this question agreed that they could not remember what their Year 7 choice had been and, of the remaining 33 pupils, 19 pupils (28.8% of the respondents) declared that their preference had changed from Year 7. Fourteen pupils (21.2% of respondents) reported that their Year 8 choice was the same as that in Year 7.

The responses of the 14 pupils who had declared that their choice of favourite subject in Year 8 was the same as that selected in Year 7 were checked for accuracy; only five of the pupils (35.7%) were correct. Out of the 19 pupils who had declared that their favourite subject had changed since Year 7, 14 pupils (73.7%) were correct, there had indeed been a change in their preferences.

Analysis by gender showed that a greater percentage of the girls, compared with the boys, had (correctly) reported that they currently had a different favourite subject than that which they had recorded in Year 7. The percentage (23%) of girls who had correctly reported that they had not changed their preference was very similar to that of the boys (21%).

7.8 Comments

The comparisons made in this Chapter must be interpreted with caution. The mean attitude to science scores in the primary phase were slightly raised by the removal of the score for the 'materials' topic (see Chapter 5) and so comparisons of the *adjusted* mean scores for science with those towards other subject areas may not be entirely fair. Also, the variation in the content of the humanities topics covered during the primary phase meant that comparison of year-on-year changes for topics in the humanities were inappropriate and item analysis of the individual topic data was not possible.

In Year 5 the science topics received significantly higher scores than the non-science (humanities) topics but, by Year 6, the situation had been reversed and the difference between the girls' attitudes to the two types of topics was greater than that for the boys. The popularity of the humanities appeared to decline, however, between Years 7 and 8. In both humanities and science, "making and doing" tasks were popular but, apart from comments from three Year 6 girls on the perceived difficulty of science (there were no comments on the difficulty of the humanities topics), there was no obvious explanation for the swing towards the humanities and away from science during Year 6. In view of the comments made on the perceived repetition of content in Year 6 science lessons, it was possible that some perceived repetition of content had reduced the pupils' enthusiasm for science. The humanities lessons which covered several different topics (with different titles) may have been seen by the pupils as having more 'new' and interesting material on offer. The nature of the science curriculum in Year 6 was such that it aimed to 'build on' most of the topics which had already been discussed in Year 5 and it was possible that this was seen by the pupils as a repetitive process rather than as an extension of their earlier work.

The pupils' comments suggested that freedom of expression and 'fun' teachers, particularly in the humanities, created more positive attitudes to the arts subjects than to science which was often regarded as too 'structured'. The less pleasant laboratory environment with its 'uncomfy' stools demonstrated some of the reasons underlying the pupils' lack of enthusiasm for the sciences in the secondary phase.

As well as the possible effects of some of these "in-school" factors on pupils' attitudes to science, there may be links between the pupils' other activities (both "in-school" and "out-of-school") and the formation, or stabilisation, of their attitudes to school science. Some of these activities - as well as the pupils' experiences of transfer between primary and secondary phases - are discussed in Chapter 8.

Chapter Seven: "In-school" factors - popularity of school science compared with other subject areas

7.9 Summary

This Chapter attempted to examine the pupils' attitudes to science lessons compared with those towards other school subjects (particularly the humanities in Years 5 and 6) and explained why, particularly in the primary phase, fair comparisons between the data were difficult to achieve.

In the primary phase, there were no significant gender differences in the pupils' mean attitude scores to the humanities topics. There was no significant difference between the boys' mean attitude scores towards science and the humanities topics in Year 5 but, by Year 6, there appeared to be a highly significant difference in favour of the humanities. For the Year 5 girls, there was a significant difference between the mean scores in favour of the science topics but, in Year 6, this was reversed so that (as with the boys) there was a significant difference in favour of the humanities topics. There was good agreement between the data for the mean attitude scores to science and to the humanities for the cohort pupils *(n=71)* and those for the whole year group *(n=102)*.

Although practical activities in both science and the humanities were favoured by the pupils, the sense of drama attached to historical events generated enthusiasm (particularly by the boys) for some of the topics in the humanities. Visits (to an Elizabethan manor house) and residential visits to the Isle of Wight were also positive attractions. 'Finding out' about the past was linked with positive attitudes, by both boys and girls, to the humanities – this may suggest alternative ways (now under discussion) of presenting some parts of the science curriculum. Humanities topics as well as science topics attracted criticism from some pupils about the amount of writing involved. The primary age girls generally held more extreme attitudes than the boys about science compared with other subject areas. An examination of the pupils' qualitative comments gave relatively little explanation for this although three girls, but no boys, commented on the perceived difficulty of science.

The pupils' favourite subject areas during the four years of the study were presented. In Years 7 and 8, the girls showed more enthusiasm than the boys for the performing arts. By Year 8, the number of both boys and girls regarding English (where perhaps more opportunities for drama were now being incorporated) as a favourite subject had increased from 6 to 19.

A significant gender difference in preferences for Design and Technology was noted in Year 7 with almost twice the percentage of boys, compared with girls, recording it as their favourite subject. Humanities appeared to be the only area where the pupils' positive relationship with the teacher was regularly cited as the main reason for their choice of 'favourite' subject. Mathematics was the only curriculum area where a strong link was suggested in the qualitative responses between the pupils' perceived performance in the subject and the selection of the subject as their 'favourite'.

Only five pupils in Year 6, and 4 pupils in Year 7, included 'science' as a favourite subject area. By Year 8, only three pupils recorded science as their favourite subject and the humanities also appeared to have declined in popularity.

Some possible explanations for the widening gap between the mean attitude scores for the humanities and science topics between Years 5 and 6, and for the lack of enthusiasm for science in the secondary phase were suggested. The data for the cohort and non-cohort pupils' preferences were compared and some minor differences noted.

Chapter Eight: "Out-of-school" activities and attitudes to school science

Introduction

Outside the confines of the school science laboratory, the vast majority of pupils will be involved in activities, hobbies and interests which may, to various degrees, supplement their understanding of, and attitudes towards, school-based science. This Chapter examines some of the data on the pupils' "out-of-school" interests and activities and compares them with data on various measures of the pupils' attitudes to science. Some of the pupils' views of school science, pre- and post-transfer to secondary school are also included.

8.1 "Out-of-school" activities and "in-school" learning

The final question on the Year 5 questionnaire, Appendix 4.1, aimed to elicit some information about the pupils' "out-of-school" activities. It was also anticipated that it might provide some information which could be used to verify the parental responses in Year 6 (see Chapter 9).

The last part of the question was included as an "extension" question, to see whether any of the children were able to identify any relationship between their "out-of-school" activities and their "in-school" learning. Only 7 pupils did not attempt to make a link; most of the links were well thought out for the age group involved and the pupils made links between e.g. cookery, weighing things and mathematics (OLU04, a girl); nature and science ("concentrate, listening, finding out about poisonous things", XLD15, a girl); collecting stamps and history (UNW19, a girl) and, most commonly, sport and improved physical fitness for playing in school teams, or musical activities and improving standards of performance in the school orchestra. In the event nearly all the Year 5 children provided a wealth of detail about their "out-of-school" activities and the level of support they gained from both inside the family and from outside agencies. The vast majority undertook some type of joint activity together with, or supported by, their parents.

8.2 Relationships between pupils' "out-of-school" interests and measures of attitudes to science

8.2.1 The primary phase

The wealth of qualitative data provided on the Year 5 questionnaires presented a snapshot of primary pupils' life styles in 1995 and, from these data, it was possible to devise a coding frame which grouped the child's activities, hobbies and interests into 5 different categories:

1. *'individual interest (non-sporting)'*

   nature, gardening, animals, cooking;

   reading, writing stories, drawing;

   collecting things (shells, rocks, stickers, stamps, coins, "Beanos", thimbles, keyrings, rubbers, badges)

2. *'performing arts'*

   music (active playing and passive listening), acting, dancing;

3. *'sport (indoor and outdoor)'*

   football, tennis, cricket, baseball etc., athletics, gymnastics, ice-skating, swimming, roller-blading;

4. *'other outdoor'*

   fishing, riding bikes, climbing trees, horse-riding, camping, rock-climbing, cycling

5. *'group activities (non-sport)'*

   Cubs, Brownies, Guides, Scouts.

This system of coding was used as a basis for categorising the pupils' other activities (e.g. table tennis, sailing, snooker etc.) which were recorded in the subsequent years of the study. In Year 6, virtually all the pupils recorded one or more "out-of-school" activities - lists of all the activities undertaken in Years 5 and 6 (see Figs. 8.1 and 8.2) are included in Appendices 8.1 and 8.2.

Fig. 8.1: Outside interests, hobbies and activities (Year 5)

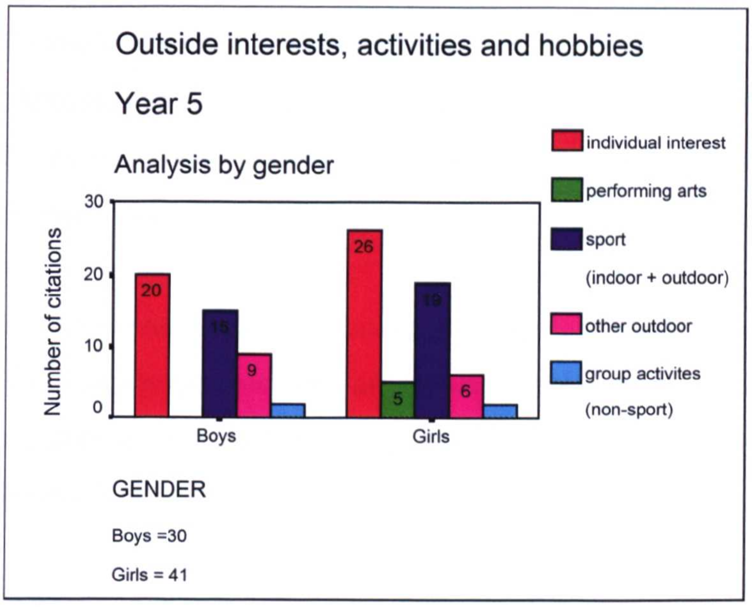
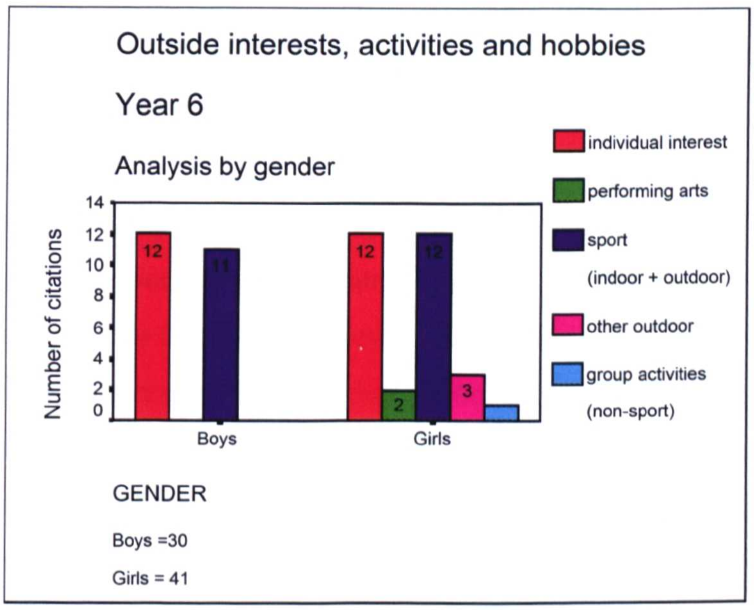


Fig. 8.2: Outside interests, hobbies and activities (Year 6)



The primary pupils were involved in a wide range of activities but examination of the data for any relationship between primary pupils' *specific* interests compared with various measures of their attitudes to science was not undertaken as, in most cases (apart from football), there were too few cases for each activity for any subsequent analyses to be meaningful. Apart from some of the sporting activities it was not always clear whether the activity was carried out indoors, or outdoors, and whether the activity was carried out alone, or with others and so categorisation on this basis was unlikely to be reliable.

After removal of outliers from the data, one-way ANOVA comparisons of various measures of attitudes to science[1] were undertaken between the mean scores of the Year 5 pupils who participated, and those who did not participate, in the five categories of activities - see Appendix 8.3. Where there were large differences in group size or significant differences in the homogeneity of variance, Mann Whitney tests of significance were performed (Kinnear and Gray, 2001).

The mean attitude scores over all science modules and the *adjusted* mean physical science scores of those Year 5 pupils who recorded an interest in individual, non-sporting activities (category 1) were significantly higher ($p<0.05$) than those of the pupils who did not record an interest in such activities - see Appendix 8.3.

There were no significant differences however between the mean scores of three measures of attitudes to science (mean attitude to science score over all modules[2], mean attitude score to the physical sciences[3] and attitudes to investigations) of the pupils who recorded an interest, and those who showed no interest, in the performing arts, other outdoor activities or group activities - see Appendix 8.3.

However, 48 pupils (58%)[4] participated in sporting activities (category 3) and nine pupils participated in 'other outdoor activities' (category 4) e.g. horse-riding, but did not record any of the sporting activities listed in category 3. When categories 3 and 4 were combined, the percentage of the cohort involved in either, or both, of these activities was 80.2%; no significant differences were, however, detected between the mean scores of various measures of attitudes to science of those pupils who participated, and those who did not participate, in some sort of sporting activity and/or other outdoor activities.

Although, the *adjusted* physical sciences mean score *(3.72)* for the Year 5 pupils who participated in sporting activities was higher than that of the pupils who did not participate in sports *(3.62)*, the difference was not statistically significant. Nor were there any significant differences between the groups in their mean attitude scores over all science modules or in their mean attitude scores to investigations (see Appendix 8.3).

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[1] Measures used in Year 5 were the mean attitude scores over all science modules, the *adjusted* mean score for the physical sciences (see Chapter 5) and attitudes to investigations.

[2] excluding score for 'materials' topic.

[3] excluding score for 'materials' topic.

[4] Keys et al. (1997) reported that about 80 percent of the Year 5 pupils regularly participated in sporting activities.

Although, in Year 6, a similar pattern was noted to that in Year 5 between the science measures[5] for the participants, and non-participants, in category 1 ('individual, non-sporting interests') the differences between means were not statistically significant). For those Year 6 pupils who showed interest in sporting activities (category 3) and those who did not, there were no significant differences in their mean scores over all science modules, the *adjusted* mean attitude score for the physical sciences, the mean score for 'liking science (compared with other subjects) in Year 6' or with their attitudes to investigations (Appendix 8.3).

8.2.3 The secondary phase

In the secondary phase, the hobbies and "out-of-school" sporting activities continued to be wide-ranging (Appendices 8.4 and 8.5). A significant difference *($p<0.05$)* in the mean attitude scores (over all science modules) was detected between those pupils who recorded category 1 individual, non-sporting interests *(3.80)* and those who did not *(3.23)* – see Appendix 8.3. No significant differences were, however, detected between the mean scores of the various measures of attitudes to science of those pupils who participated in "out-of-school" sporting activities and those who were not involved in such activities.

The Year 7 questionnaire had included a question (Appendix 4.3, Question 5) which was specifically related to the *strength* of the pupils' interest in P.E./games. It had originally been anticipated that this question might yield some additional data which could be correlated with the data on various measures of pupils' attitudes to science. A significant difference *($t=3.038$, $df=69$, $p=0.003$)* between the mean of the boys' *(4.67, SD 0.84, $n=30$)* and girls' *(3.78, SD 1.42, $n=41$)* attitude scores for P.E. was identified[6] but no statistically significant correlations were detected between the attitude scores for P.E. and the various measures of pupils' attitudes to science. There were no significant differences between the means of the boys', or the girls', scores in the cohort and non-cohort groups; this suggests that the cohort pupils' responses were fairly representative of the year group as a whole.

By Year 8, the mean scores for attitude to science over all science modules *(3.37, SD 0.71)* and for interest in science *(3.45, SD 1.05)* for those 58 pupils who recorded "out-of-school" sporting activities, were higher than those for the 12 non-participants *(2.83, SD 1.22*

[5] Measures of the perceived difficulty of science and liking for science compared with other subjects were also included in the analyses - see Appendix 8.3.

[6] supported by data from the non-cohort pupils *($t=2.706$, $df=77$, $p=0.008$, $n=78$).*

and *2.50, SD 1.31* respectively) . There was, however, a great disparity in group sizes and the Mann Whitney test suggested that only for the interest in science mean scores was the difference significant *(Z=-2.496, p=0.013)* – see Appendix 8.3.

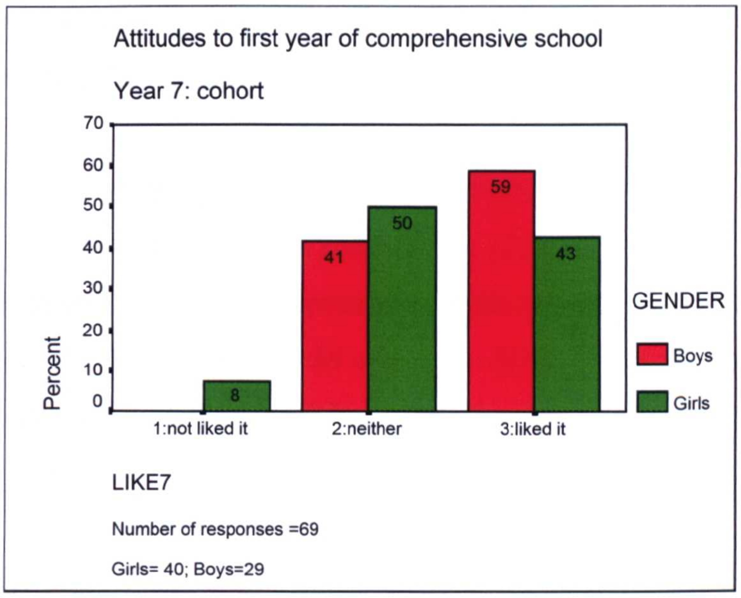
8.3 Transfer to secondary school: pupils' views of science

At the end of Year 6 the pupils had been asked (Appendix 4.2, Question 10) to comment about their expectations of the 'new' school to which they would transfer in September. A positive attitude to the school itself, its environment, culture and ethos, may be an important influence on pupils attitudes' to their studies (including science) during their years of compulsory schooling; an 'Enjoyment of school scale' was included in the analyses of the data from the Second International Science Study (Keys, 1987).

A large number of pupils participating in the longitudinal study mentioned the attraction of "making new friends and having different lessons" (e.g. UNW06, a girl). Numerous other comments could be grouped into categories such as lesson content, the anticipated difficulty of the lessons, homework and the teachers or teaching style; concern about noise and the size of the site together with possible problems associated with movement around the site; the differences in the school day and the opportunities for sport/clubs and fear of bullying or other personal problems - some of the examples of the pupils' views are given in Appendix 8.6.

A year later, at the end of Year 7, an opportunity was taken (Appendix 4.3, Question 3) to ask the pupils whether or not, the first year had met with some of their expectations and whether they liked their 'new' school.

Fig. 8.3: Attitudes to comprehensive school at end of Year 7



Whilst more than half (58.6%) of the boys who responded to the question showed positive attitudes to their new school, the girls were not so enthusiastic. Eight per cent of the girls (but no boys) recorded negative scores. As the data were not normally distributed, an independent samples *t*-test was replaced by the Mann Whitney test; no significant gender difference was detected *(Z= -1.534, p=0.125)*. Correlations between the score for liking the new school and measures of attitudes to science were weakly positive but not statistically significant (for either the cohort or the non-cohort pupils).

8.4 Cohort and non-cohort pupils in Year 7: a comparison

An examination of the data from the non-cohort pupils who had joined the comprehensive school from other (non-participating) primary schools suggested that pupils from one of these non-cohort schools (School FG), which was adjacent to the secondary school premises, were reporting generally more positive attitudes to the secondary school than were the pupils from the three participating primary schools.

There was a larger percentage of '3' ('liked it') scores at School FG and this may possibly be due to the early formation, and stability, of some positive, pre-transfer attitudes of the pupils from School FG because of its close proximity to the comprehensive school. A large majority of pupils at School FG transferred to the comprehensive school and, in 1997, the number of pupils (46) from this single school greatly exceeded the number of pupils (12) entering the comprehensive school from various other schools in the surrounding villages. The weighting given by the large percentage of positive scores from the pupils of this single, large primary school (FG) may explain why the mean attitude score for 'liking the new school' of the non-cohort pupils as a whole was very slightly higher[7] *(2.54, SD 0.66, n=79)* than that of the cohort pupils *(2.45, SD 0.58, n=69)*.

There was no significant difference *(t=-0.970, df=60, p=0.336)* between the mean attitude score for 'liking the new school' of the cohort boys *(2.55, SD 0.51, n=29)* and the non-cohort boys *(2.68, SD 0.68, n=31)* or between the mean attitude scores of the cohort and the non-cohort girls (*2.37, SD 0.63, n=38* and *2.46, SD 0.71, n=48* respectively)[8]. This suggests that the cohort pupils monitored in this study were generally representative of the year group as a whole.

8.5 Stability of interests

Between Years 5 and 6 the number of pupils recording a preference for 'individual interest: (non-sporting) activities' dropped from 46 to 24. After a further dip in Year 7, interest in individual activities other than sport increased in Year 8. In Years 5 and 7 there were suggestions that the pupils who participated in these (category 1) activities had higher scores for some of the measures of attitudes to science[9] than their colleagues who did not participate in such activities.

Between Years 5 and 8, very few pupils recorded "out-of-school" participation in non-sporting group activities (e.g. Guides, Scouts, etc). There appeared to be a shift towards more of the small group activities e.g. 'going shopping' (3 girls) fairly typical of adolescent behaviour as the pupils progressed towards Year 8. 'Social' activities, e.g. 'playing with friends', was recorded by 6 pupils in Year 5 and 7 pupils in Year 6. By Year 7 twelve girls and 1 boy and, in Year 8, 13 girls and a (different) boy recorded socialising ('chilling out with my mates': girl, XLD 09) as an "out-of-school" activity.

Interest in cars, bikes and model planes over the 4-year period was shown by only six individuals (5 boys and 1 girl) but interest was not recorded for any longer than two consecutive years; one boy, XLD 22, declared an interest in 'motor bikes' in Years 6 and 8 but not in Year 7.

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[7] the difference was not statistically significant *(t=-0.926, df=146, p=0.356)*
[8] *(t=-0.610, df=84, p=0.544)*
[9] Year 5: mean attitude to science score (over all modules) and mean attitude score to physical science modules. Year 7: mean attitude to science score (over all modules).

Only in Year 6 was there any significant difference *(Z=-2.325, p=0.020)* between the (lower) mean attitude scores to the physical science modules[10] for those who participated in performing arts *(2.44, SD 0.68, n=8)* and those who did not participate *(3.19, SD 0.97, n=63)*. The non-participants also had a significantly higher *(Z=-2.070, p=0.038)* mean attitude score *(2.30, SD 0.64, n=63)* to investigations than did the participants *(1.75, SD 0.71, n=8)* but there was a great disparity in group sizes (hence the use of the non-parametric Mann-Whitney test).

There was increasing participation in "out-of school" individual sporting activities between Years 5 to 8 (11, 32, 39 and 37 pupils respectively declaring an interest in these activities) and, between Years 7 and 8, preferences appeared to be fairly stable. The boundary between "in-school" and "out-of school" sporting activities may well have been rather vague due to school team matches often being played after normal school hours. The secondary school had excellent sporting facilities and the pupils' preferences for P.E./sport on transfer to the school were high – it would appear, therefore, that there was a good uptake of both "in-school" and "out-of-school" sporting activities by the secondary pupils.

In Year 8, the pupils who participated in "out-of-school" sport demonstrated a higher mean score *(3.37, SD 0.71, n=58)* for their attitudes to science (over all modules) compared with their colleagues who did not participate in such activities *(2.83, SD 1.22, n=12)*. Again there was a large disparity in group sizes and no significant difference between the means was detected (using the non-parametric Mann Whitney test). There was, however, a significant difference *(Z=-2.496, p=0.013)* between the mean scores for interest in science of those who participated in "out-of-school" sporting activities *(3.45, SD 1.05, n=58)* and those who did not participate in such activities *(2.50, SD 1.31, n=12)*.

[10] excluding the score for the 'materials' topic

8.6 Potential scientists: "out-of school" interests

The data generated in this study suggested that the vast majority of pupils experienced a wide-range of "out-of-school" activities during both their primary and secondary years. As only five pupils had recorded science as a 'favourite' subject in Year 6, and only three of the pupils (1 boy, 2 girls) had an interest in "being a scientist", it was not possible, therefore, to link any particular "out-of-school" interests in Years 5 and 6 with the potential to follow a career in science[11] (see Table 8.1).

Table 8.1: Comparison of hobbies and "out-of-school" interests (Years 5 and 6)
(Pupils recording science as a favourite subject in Year 6)

Pupil code	**Hobbies and "out-of-school" interests**	
	Year 5	**Year 6**
OLU03 (boy)*	Football; cooking	sport
XLD01 (girl)	Nature, swimming, baseball	swimming
XLD05 (girl)	Nature, P.E., swimming	Drama Club
XLI04 (girl)*	Collecting stickers and rubbers, swimming, roller-blading	Netball, Kung Fu, running
XLI15 (girl)*	swimming	Running and bike riding
*** Answered "Yes" to "Might you like to be a scientist one day?"**		

Other "out-of-school" factors, such as parental experiences of, and attitudes towards, science may also be linked with pupils' attitudes to school-based science and some of these factors are discussed in Chapter 9.

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[11] See also Chapter 10.3.2

Chapter Eight: "Out-of-school" activities and attitudes to school science

8.7 Summary

This Chapter examined the pupils' "out-of-school" activities and looked for any possible links between participation in these activities and various measures of the pupils' attitudes to science. Some of the pupils' views on science pre- and post- transfer were included.

In Year 5, the mean attitude score over all science modules and the *adjusted* mean physical science score of those pupils who recorded an interest in individual, non-sporting activities (category 1) were significantly higher ($p<0.05$) than those of the pupils who did not record an interest in such activities (see Appendix 8.3). The percentage of pupils (80.2%) who indulged in 'sporting activities' and/or 'other outdoor activities' was very close to that (80%) found by Keys (1997) and this is reassuring in view of current concern (Revill, 2002 and British Broadcasting Corporation, 2002c, 2003b) about the decline in physical activity amongst young children. There was, however, no significant difference in the mean attitude to science scores (for all topics except the materials topic) for the Year 5 pupils who participated in sporting activities and those who did not.

In Year 6, no significant difference was observed between the mean scores of the sporting and non-sporting groups for any of the measures of attitudes to science but, in Year 7, the mean attitude score over all science modules *(3.80)* for those pupils who enjoyed individual, non-sporting activities was significantly higher ($p<0.05$) than that of the pupils who did not record an interest in such solitary activities.

In Year 7, significant gender differences were detected, in favour of the boys, for the mean attitude score to P.E./games (which would have included some "out-of-school" sporting activities) but no statistically significant correlations were detected between the pupils' mean attitude score for P.E. and the various measures of attitudes to science. By Year 8, however, the differences in the attitude measures (mean attitude to science scores over all science modules and for interest in science) for those who recorded "out-of-school" sporting activities, and those who did not, were significant ($p<0.05$ and $p<0.01$ respectively). No significant differences were detected between the responses of the cohort, and the non-cohort pupils and this suggests that the cohort pupils were representative of the year group as a whole.

There was increasing participation in "out-of-school" individual sporting activities between Years 5 to 8 (11, 32, 39 and 37 pupils respectively declaring an interest in these activities) and, between Years 7 and 8, preferences appeared to be fairly stable. In Year 8, the pupils who participated in sport appeared to demonstrate significantly higher mean scores for their attitudes to science (over all modules) and for their interest in science compared with pupils who did not participate in "out-of-school" sports ($p<0.05$ and $p<0.01$ respectively) but the disparity in the group sizes was considerable and this finding should be interpreted with caution.

From the pupils' perspectives, the transfer to the secondary school was generally a positive experience, the boys tended to be more positive than the girls. The data generated in this study suggested that the vast majority of pupils experienced a wide-range of "out-of-school" activities during both their primary and secondary years but very few links could be determined between any particular type of activity in which the pupils engaged and various measures of their attitudes towards school science.

Chapter Nine: Parental and "home-based" factors and attitudes to school science

Introduction

One of the additional objectives of this longitudinal study was to explore the nature and strength of any links between parental experiences of, and attitudes towards, science and various measures of the pupils' attitudes towards the subject area (see Chapter 3.5). Parental information was collected by questionnaire (see Chapter 4); the overall parental response rate was good (63%) – see Appendix 4.13.

9.1 Parental experiences of primary science

Using 5-point and 3-point scales respectively, both parents were asked about 1) their attitudes to their primary science education and 2) how they felt about investigating things when they were at primary school; in both cases a "cannot remember" box was added.

9.1.1 Attitudes towards their primary science education

Unlike the pupils' responses, the validity of these responses could not be checked against tape-recorded interviews but it appeared that a greater percentage (39%) of mothers than fathers (26%) were unable to re-call details of their primary science education. When these "cannot remember much" scores were removed from the analysis for both sets of parents (Figs. 9.1 and 9.2), the mean scores for attitudes to their own primary science education were *4.03, SD 0.66* for the mothers (*n=31)* and *4.20, SD 0.80* for the fathers (*n=35).* Although the mothers seemed particularly adamant about their lack of primary science education (see Appendix 9.1), the parents' overall impressions of their primary science education seemed to have been quite favourable.

Fig. 9.1 Mothers' attitudes to primary science

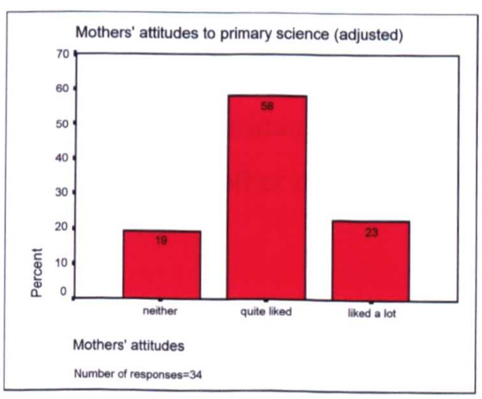
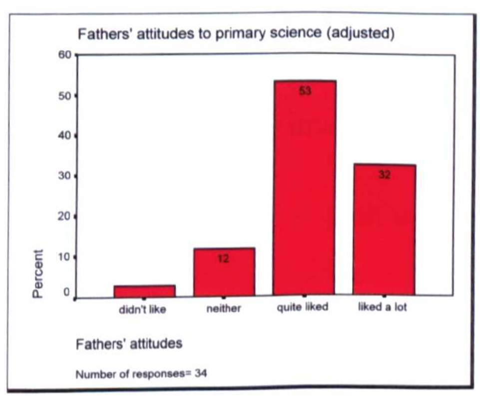


Fig. 9.2 Fathers' attitudes to primary science



There was a statistically significant correlation *($r=0.569$, $p<0.001$)* between the mothers' and fathers' attitudes to primary science. (In the 21 cases where both parents were able to recall their primary science experiences, 10 pairs of parents recorded the same attitude score, 8 of the fathers recorded higher scores than their wives/partners and, in only 3 cases, the mothers' scores were higher than those of the fathers[1]).

When the 'can't remember' scores were removed from the analyses, there were no significant correlations between maternal, or paternal, attitudes to primary science and the Year 6 pupils' *adjusted* mean attitude scores over all science modules, *adjusted* mean attitude scores to the physical sciences, interest in science lessons (compared with Year 5) or liking for science compared with other subjects. Nor were there any correlations with measures of the pupils' attitudes to science in later years.

9.1.2 Attitudes towards investigations at primary school

Fairly high percentages of both mothers (35.3%) and fathers (28.3%) who responded to the question admitted that they could not remember doing much investigation at primary school. When the 'can't remember' scores were removed from the analysis (see Table 9.1) there was a significant correlation, $r=0.542$, $p=0.001$, $n=71$, between the mothers' and fathers' scores for their attitudes towards investigations at primary school).

Table 9.1: Parental attitudes towards investigations at primary school

Parent	Number of responses	Attitude scores			
		3 liked investigating things	2 neither liked nor disliked investigating things	1 disliked investigating things	(4) cannot remember doing much investigation
Mother	51	27 (52.9%)	6 (11.8%)	-	18 (35.3%)
Father	46	28 (60.9%)	5 (10.9%)	-	13 (28.3%)

There was no significant correlation between the fathers', or the mothers', attitudes to investigations at primary school and the attitudes of their child towards investigative work in Year 6 or any other measures of the pupils' attitudes to science.

[1] These responses are in line with data collected from the parents of the entire year group before attrition (15 out of 32 pairs of parents showed similar responses, 12 fathers had higher scores than their wives/partners and only 5 mothers recorded attitude scores higher than those of their husbands/partners).

9.2 Attitudes to secondary science education

The parents were asked (Appendix 4.8, Question 3) to record on a 5-point scale their attitudes to secondary science; a "cannot remember" box was also added.

9.2.1 Attitudes towards their secondary science education

Parental re-call of secondary science was, not surprisingly, better than that of primary science – only 1 mother and 3 fathers gave responses which indicated that that they could not remember much about it. When the 'can't remember' scores were removed from the analysis, there was a significant correlation *($r=0.613$, $p<0.001$, $n=71$)* between the scores for the mothers' and fathers' attitudes to secondary science *(means: 3.80, SD 0.96, $n=49$* and *3.95, SD 0.90, $n=43$* respectively) although secondary science seems to have left a more positive impression on the fathers than on their wives/partners (see Appendix 9.1).

Fig. 9.3: Mothers' attitudes to secondary science

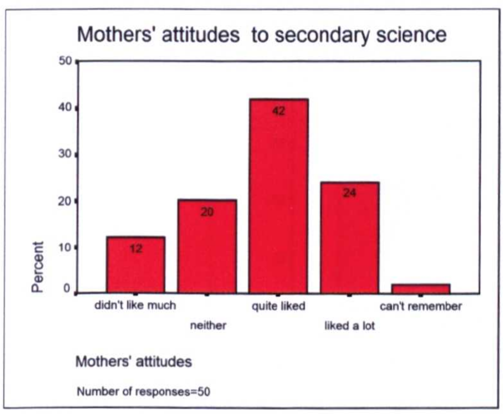
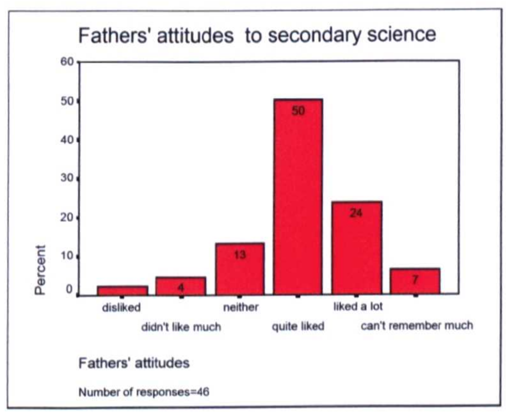


Fig.9.4: Fathers' attitudes to secondary science



For both mothers and fathers, positive correlations *($r=0.631$, $p=0.001$, $n=71$* and *$r=0.769$, $p=0.001$* respectively) were detected between their attitudes to secondary science and attitudes to primary science. There were no significant correlations[2], however, between the mothers', or fathers', attitudes (*means: 3.80, SD 0.96, $n=49$* and *3.95, SD 0.90, $n=43$* respectively) to their secondary science education and their children's *adjusted* mean science scores and physical science scores, interest in science lessons compared with Year 5, liking for science compared with other subjects, liking for investigations in Years 6, 7 and 8 or any other measures of their attitudes to science.

[2] A weak, barely significant correlation *($r=0.234$, $p=0.049$, $n=71$)* was suggested between the fathers' attitudes to secondary science and the pupils' attitudes to science (over all modules) in Year 7.

9.2.2 Attitudes to biology, chemistry and physics

In order to establish whether there might be a link between parental, and pupil, preferences for chemistry, physics or biology, parents were asked if they had a preference for one of the three main sciences at secondary level. Of the 40 mothers who gave a specific preference, the numbers preferring biology, chemistry and physics were 29 (72.5%), 8 (20%) and 2 (5%) respectively; with one mother (2.5%) recording no preference. Twenty-six fathers gave their preferences: 9 (34.6%) for biology, 6 (23.1%) for chemistry and 11 (42.3%) for physics. There were no statistically significant relationships between the mothers', or fathers', preferences for biology, chemistry or physics and the pupils' attitudes to those subjects in Year 8.

9.3 Level of parental science education

Parents were asked (Appendix 4.8, Question 5) to indicate the level[3] of their science education and, if they studied science beyond age 16, which was their main area of study.

Fig. 9.5: Level of mothers' science education

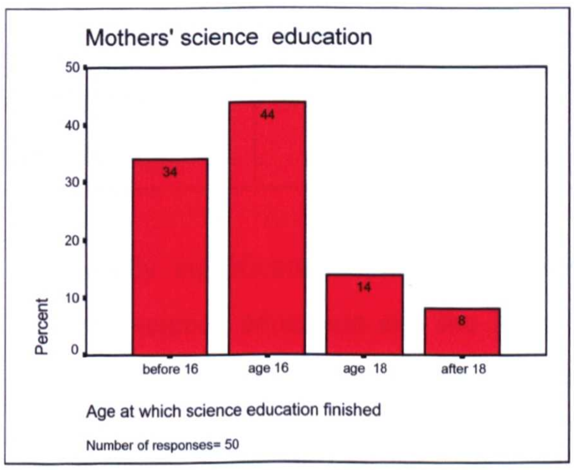
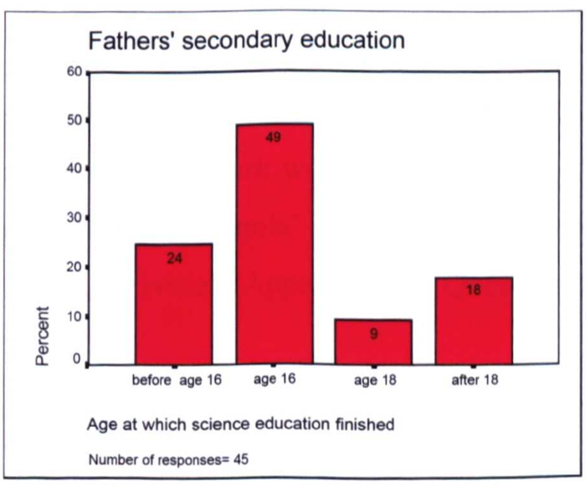


Fig. 9.6: Level of fathers' science education



[3] finished *before* age 16, or studied *up to* age 16, age 18 or *beyond* age 18.

Seventeen (34.0%) of the mothers, compared with 11 (24.4%) of the fathers, had given up studying science before age 16. Fourteen per cent of the mothers[4] and 9% of the fathers[5] had studied science as far as 'A' level or equivalent and, beyond age 18, only 4 (8.0%) of the mothers, compared with 8 (17.6%) of the fathers, had studied any science. There were, perhaps not surprisingly, statistically significant relationships between the length of the mothers', or fathers', science education and their attitudes to primary or secondary science (see Table 9.2).

Table 9.2: Correlations (Spearmans) between length of parental science education and attitudes to primary and secondary science

	Length of science education	
Attitudes to	Mothers'	Fathers'
Primary science	*r=0.640; p<0.001*	*r=0.760; p<0.001*
Secondary science	*r=0.666; p<0.001*	*r=0.777; p<0.001*
Investigations at primary school	*r=0.618; p<0.001*	*r=0.598; p<0.001*

There were no statistically significant correlations between the length of either the mothers', or the fathers', science education and the Year 6 pupils' mean attitude score over all science topics, the *adjusted* mean score for the physical sciences, attitudes to investigations, interest in science lessons (compared with Year 5) or liking for science compared with other subjects.

9.4 Pupil: parent relationships and 'tinkering'

One of the supplementary objectives of the research was to assess whether the pupils' attitudes towards investigative work were associated with the parents' attitudes towards questionnaires had sought the pupils' perceptions of parental help in "out-of-school", including home-based, activities (Appendix 4.1, Question 4) and it was anticipated that

[4] Main subject area(s) studied at this level were given as: biology (3), chemistry (1), chemistry, biology and rural biology (1) and physics (1).

[5] Main subject area(s) studied at this level were given as: biology (1), physics (1), chemistry and physics (2) and physics/technical drawing/engineering science (1).

these responses might validate the parental comments concerning the involvement with their child in various activities.

Whilst help might be offered to the pupil from either, or both parents, an active involvement in 'tinkering' activities was one of the issues explored in the parental questionnaire (Appendix 4.8, Question 7). Seventeen (56.7%) of the boys reported that they received help from their mother in various "out-of-school" activities and an identical number reported that they had help from their father; eleven of the boys (36.7%) received help from both parents. Twenty-six girls (63.4%) reported help with their activities from their mothers and 22 (53.7%) received help from their fathers (18 of these girls received help from both parents).

9.4.1 Parental 'tinkering' during the secondary years of education

Analysis of the positive responses about parental "tinkering" revealed that 14 mothers out of the 46 (30.4%) responding to this question and 31 (out of 45) fathers (68.9%) had enjoyed exploring and investigating things during their secondary school years.

Some of the examples of 'tinkering' which were provided on the parental questionnaires are shown in Appendix 9.1. Six of the mothers' comments related to 'tinkering' with relatively small devices such as miniature engines, clocks and watches, radios etc. although one mother admitted to "learning about basic electrical wiring" and another mother helped her father with car maintenance. Five mothers enjoyed 'chemistry' experiments such as experimenting with liquids e.g. "to see if they changed colour" or "mixing colours together". Only two mothers who recorded a positive response to 'tinkering' specifically referred to interests in the area of the biological sciences; one mother qualifying her response with reference to "dissecting animals" and "the study of insects".

Virtually all of the (25) fathers' comments also referred to some form of 'tinkering', taking apart, or investigating, items such as bicycles, motorbikes, car engines, watches, clocks and pens. Five fathers included positive comments about chemistry experiments in their comments on 'tinkering'; one father mentioned "dissecting insects and worms". There did not appear to be any statistically significant relationship between the mothers' (or the fathers') enjoyment of 'tinkering' in their secondary years and the pupils' attitudes to investigations in Years 7 or 8; it would be unwise to draw any more specific conclusions in view of the relatively small number of parents providing written comments.

9.4.2 Current interest in 'tinkering'

The parents were also asked (Appendix 4.8, Question 7(b)) whether they currently 'tinkered' with things around the home (e.g. in the kitchen, garden or garage) and, if so, whether their (Year 6) child usually showed an interest in what they were doing.

9.4.2(i) Mothers' experiences

Fourteen of the 46 (30.4%) mothers who responded to this question reported that they had enjoyed 'tinkering' with things when they were at secondary school and 11 of these mothers, together with 10 who did not 'tinker' at secondary school age, declared that they currently 'tinkered' with things around the kitchen, garage or garden. With one exception, these mothers thought that their child took an interest in what they were doing. There were three main areas of activity: gardening, investigating (or repairing) mechanical or electrical devices and cooking. It did not appear that mothers' attitudes to their child reinforced gender stereotypes; mothers introduced their sons to "cooking experiments" (XLD16) and daughters to "bicycles, mowers and farm equipment"(XLD21) – see also Appendix 9.1.

9.4.2(ii) Fathers' experiences

Thirty-one of the 45 (68.9%) fathers reported that they enjoyed 'tinkering' with things at secondary school and 27 of them still enjoyed doing this in 1996. Together with 8 fathers who had reported that they were not interested in 'tinkering' during their secondary school years, a total of 35 fathers gave a positive response to current 'tinkering' activity. Nineteen fathers (54.3%) thought that their child took an interest in what they (the fathers) were doing and some examples are given in Appendix 9.1.

The fathers, like the mothers, were generally keen to involve both boys and girls in 'tinkering' activities and gardening and the repair of machinery or other devices seemed to predominate. The range of activities in which the fathers were engaged were those traditionally thought to be associated with the traditional 'male' role-model: D-I-Y, building and gardening work, car repair and, to a lesser extent, computer studies. Only one father included any comment about involving his daughter (XLD03) in any aspect of food preparation: 'sanding wood, changing plugs, making tea'.

The Year 5 children had not been asked about 'tinkering' as such but only 4 boys and 1 girl declared an interest (see Chapter 8) during Years 5 and 6 in mending/repairing activities, i.e. those activities which would normally be regarded as involving 'tinkering'. In Year 6, where comments were available from the pupils and one, or both, of the parents, most of the comments were consistent:

> *Extract from tape-recorded interview with a pupil (UNW09, a boy)*
>
> ***"Was there anything that they (your parents) did around the house that you watched and joined in with?"***
>
> **Pupil:** "My dad and his gardening"
>
> *Extract from parental questionnaires for UNW09:*
>
> **Father:** "He's interested in pest and disease control in the garden, compost-making techniques and methods of preserving the produce."

The accuracy of parental reporting on 'tinkering' could not be validated in most of the cases (except where tape-recorded comments were made by the small sub-sample of pupil interviewees) and so any conclusions drawn from these data must be regarded with caution. Although a brief explanation of 'tinkering' had been included as a footnote on the questionnaires[6], the parental responses probably reflected a wide range of interpretations. To some parents, even a small degree of mutual participation with their child might be reported as 'tinkering' whereas other parents might take the view that 'tinkering' should be interpreted as involving quite a sophisticated degree of parental explanation of scientific principles. As it was also clear from an examination of the qualitative data that the pupils' perception of 'help' from parents, and the parents' perceptions of their involvement with their children in 'tinkering' activities, were not necessarily always consistent, a re-evaluation of the data from both pupils and parents was, therefore, undertaken.

9.4.3 Examination of pupils' and parental data: a re-evaluation of 'tinkering'

Most of the parents perceived a high degree of involvement with their son's, or daughter's, 'tinkering' activities (Appendix 4.8) and it appeared that many parents had probably incorporated other activities (e.g. those associated with equipment used in some of the activities such as cooking, photography, nature study or computers) into their personal definitions of 'tinkering'. For compatibility, the Year 5 pupils' acknowledgement

[6] Appendix 4.8

of parental 'help' (Appendix 4.1) was therefore widened to include help with other activities which might also include a 'tinkering' element.

For 5 of the (17) boys (29.4%) who acknowledged help from their mothers, their mothers thought they were jointly involved in 'tinkering' activities with their sons. For 9 of the (17) boys (52.9%) who recorded help from their father, their fathers also recorded an involvement with them in 'tinkering' activities.

Twenty-six girls reported that they received help from their mothers and seven of these mothers (26.9%) reported that they were involved in joint 'tinkering' activities with their daughters. Twenty-two girls received help from their fathers and 9 (40.9%) of these fathers reported a mutual interest with their daughters in 'tinkering'. There was perhaps very little difference between the mothers' involvement with either their sons or daughters but the percentage of fathers who involved their sons was noticeably higher than the percentage who involved their daughters. The data from this small sample suggest that, generally speaking, fathers are still the prime 'tinkerers' and they are more likely to get involved with their sons, rather than their daughters, in 'tinkering' activities.

There was a statistically significant association ($X^2=6.75$, $df=1$, $p=0.009$) between the mothers' current involvement with the child in 'tinkering' activities and the fathers' involvement with the child in 'tinkering'; this may reflect the character of the marriage/relationship in that, in this respect, both mother and father exhibit similar behavioural tendencies.

Before an attempt was made to relate the data on parental 'tinkering' to various measures of the pupil's attitude to science in Years 6 to 8, the qualitative data on 'tinkering', together with the parents' additional comments about whether they thought that any specific activities encouraged their child's interest in science, was re-examined in an attempt to assess the level (on a 3-point scale) at which this mutual 'tinkering' occurred. Where the qualitative data on parental tinkering suggested an element of explanation, directed exploration or where it made a specified contribution to the learning process, the parental response was scored as '3'. Where the area of the involvement was given, but there was no apparent explanation of purpose, this was scored '2'. Comments which merely mentioned a mutual 'interest' in some activity, or where no further details were given, were awarded a score of '1'.

Adjustment of data for level of mutual (parent + child) 'tinkering'

Examples:

Level 3
OLU06 (father: landscape gardener): boy
"growing things in garden and **finding out** about how they grow"

Level 2
OLI08 (mother – no other occupation given), girl
"changing plugs, decorating,fixing items to the wall

Level 1
OLI08 (father, heating engineer), girl
"general interest"

When these re-classified parental data for current 'tinkering' (which took account of the different levels of 'tinkering') were examined no correlations were, however, detected between the level of the mothers' involvement in 'tinkering' and the Year 6 pupils' *adjusted*[7] mean attitude to science score and mean physical science score, interest in science lessons compared with Year 5, liking for science compared with other subjects, attitudes to investigations in Year 6, or any of the other measures of attitudes to science in Years 7 and 8.

However, for the fathers', there were suggestions of weak correlations between their level of involvement in tinkering and the pupils' *adjusted* mean score for the physical sciences in Year 6 *($r=0.249$, $p=0.036$, $n=71$)*, the pupils' attitudes to investigations in Year 7 *($r=0.283$, $p=0.018$, $n=69$)* and the Year 8 pupils' interest in science compared with Year 7 *($r=0.243$, $p=0.042$, $n=71$)*. It was also clear from the responses that, whilst many parents thought that they were involved with their child in 'tinkering' (according to whatever interpretation they placed on it), several other parents considered that they were involved in activities – other than 'tinkering' – which might particularly encourage their child's interest in science.

9.5 Parental encouragement of children's interest in science

In anticipation that the question on 'tinkering' might be interpreted in several different ways, the final question (Appendix 4.8, Question 7(c)) had been included to elicit whether the parents thought that any of the *activities* which they shared with their Year 6 child might particularly encourage his/her interest in science. Some examples of the mothers' and fathers' comments about these shared activities are shown in Appendix 9.1.

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[7] excluding 'materials' topic.

9.5.1 Mothers' activities

Twenty (41.7%) of the mothers responding thought that some of the activities which they shared with their child might particularly encourage the child's interest in science. A wide range of activities were given – some of them very purposeful and, for the age group involved, many pre-empted national curriculum objectives.

> ***Mother's involvement with daughter, XLI21***
> "we've done easy experiments at home with vinegar and baking soda, etc, and water fountains (hot and cold waters, different colours) and explain why it works".

9.5.2 Fathers' activities

Nineteen of the 44 fathers (43.2%) who responded thought that some of the activities in which both they and their child participated might particularly encourage their child's interest in science (see Appendix 9.1).

> ***Father's involvement with son, UNW09***
> "collect insect larvae and watch them going through metamorphosis. Watched recent lunar eclipse and try to name planets and constellations."

Apart from a slight bias towards domestic and culinary activities (at the expense of some of the more 'male' activities) the range of activities which were pursued by the mothers, together with their daughters or sons, were generally the same as those recorded by the fathers and their children.

There was a statistically significant association ($X^2=21.865$, $df=4$, $p=0.001$) between the length of the mothers' science education and the mothers' perceptions that they were involved in activities which would encourage their child's interest in science (Appendix 4.8, Question 7(c)). These indications were generally supported by the qualitative data provided on the parents' questionnaires but the links must be interpreted with some caution - data were not sought on the underlying sociological and economic variables (e.g. family income, number of children in the family etc.) which could confound the issue.

Although only 19 fathers responded positively to the question, a statistically significant association was also suggested between the paternal level of science education and the fathers' involvement in activities which might encourage an interest in science ($X^2=24.036$, $df=4$, $p=0.001$). There was an apparent gender bias, towards their sons, in these (self-reported) scores for joint science-orientated activities. Out of the nineteen positive responses from fathers, thirteen (68.4%) fathers reported that they were involved in science-orientated activities with their sons; six (31.5%) were involved in similar activities with their daughters. This supports the data (see 9.4.3) on parental involvement in 'tinkering' where 52.9% of fathers who responded reported that, together with their sons, they were involved in 'tinkering' activities. Only 40.9% of the fathers declared that, together with their daughters, they were involved in similar activities.

Some of the responses to Question 7(c) were quite detailed and some encompassed a wide range of activities which were appropriate extensions of the child's learning, not only of science, but in other areas as well.

> **OLN10** (father: electronics technician), girl
> "she enjoys testing with a meter, such things a continvity *(conductivity?)* of a wire or checking if a battery is charged or flat"
>
> **UNW15** (mother: stock replenisher), girl
> "cooking-it's amazing to see the changes that occur using different ingredients and how different ways of cooking can make different changes to the same items"
>
> **XLD22** (mother: medical microbiology scientific officer), boy
> "watch documentary programmes; discuss scientific topics - body, animals, garden, growing things; buy and read together science books (nature, technology etc)"
>
> **XLD24** (father: computer systems manager), boy
> "use of computer software and use of educational books which explain the workings of the world around us and everyday objects".

The responses to the two questions, 7(b) and 7(c) might be considered to give a more complete picture of the parent-child relationship and the various activities in which both parent and child participated than the 'tinkering' question alone. However, when these 'tinkering' and 'encouraging science' scores were taken together no statistically significant correlations were suggested between either the mothers', or fathers', combined score and the pupils' attitudes to investigations in any of the Years 5 to 9.

9.6 Parents' reflections on science

Parents were asked, Appendix 4.8, Question 7(a), whether they would have liked to have studied more science (i.e. beyond the level reported in Question 5). Twenty-one of the 47 mothers (44.7%) responding to the question would have liked to have studied more science; 25 fathers (55.6% of the male responses) held similar views.

9.7 Contribution of parental factors to pupils' attitudes

It was clear from this exploration of parental attitudes that the vast majority of pupils came from supportive families where both parents were keen to encourage the children's activities, including scientifically-orientated ones, outside school. The qualitative data derived from the parental questionnaires, supported by the children's questionnaires and semi-structured interviews, were useful in suggesting some possible tendencies. In this small-scale study, relatively few parents had continued to study science beyond age 16 and the presence of any statistically significant relationships between parental, and pupils', attitudes to science should be treated with caution (see Chapter 11: limitations).

Stepwise multiple regression procedures (Kinnear and Gray, 2001) were then undertaken using the pupil and parental data generated in Years 5 to 8 (see Appendix 6.1) to examine the combination of predictor variables which, each year, would best predict the two target (dependent) variables i.e. pupils' attitudes to science over all the science topics/modules[8] and their attitudes specifically to the physical sciences.

This procedure provided greater accuracy in the prediction than univariate correlations and also allowed an examination of the degree to which each of the variables contributed to the total variance, whilst controlling for the effects of the other variables.

9.7.1 Predictors for attitudes at the end of Year 5

At the end of Year 5, the predictors (see Table 9.3) for the pupils' mean attitude score over all the science topics were the maternal involvement in the pupils' "out-of school" activities and the pupils' enjoyment of individual, non-sporting activities for example 'tinkering', collecting or classifying things, or simply reading.

The regression equation was as follows:

'sciavad5' = 2.778 + 0.444 x 'helpmum' + 0.374 x 'Yr5 act 1'

The multiple R was *0.642 (p=0.0001)* and the adjusted R^2 was *0.388* (accounting for approximately 39% of the variance in scores.

[8] excluding the 'materials' topic in Years 5 and 6

Table 9.3: Attitudes over all science topics (except 'materials') in Year 5 ('sciavad5')

Contributory variable	Standardised coefficients (beta weight)	Significance
Maternal involvement in "out-of-school" activities ***('helpmum')***	*0.444*	*0.001*
Pupils' involvement in individual, non-sporting activities ('Yr5act1')[9]	*0.374*	*0.002*

For the physical science topics (excluding 'materials'), maternal involvement was still a predictor of the pupils' attitudes together with a positive attitude towards investigative work and participation in group activities outside school (see Table 9.4).
The regression equation was as follows:

$$\text{'physavad5'} = 1.919 + 0.309 \times \text{'invest5'} + 0.382 \times \text{'helpmum'} + -0.275 \times \text{'outgrou5'}$$

The multiple R was *0.575 (p=0.0001)* and the adjusted R^2 was *0.290* (accounting for approximately 29% of the variance in scores.

Table 9.4: Attitudes to physical science topics (except 'materials') in Year 5 ('physavad5')

Contributory variable	Standardised coefficients (beta weight)	Significance
Maternal involvement in "out-of-school" activities ***('helpmum')***	*0.382*	*0.003*
Positive attitudes to investigations and practical work ***('invest5')***	*0.309*	*0.013*
Participation in group activities outside school ***('outgrou5')***	*-0.275*	*0.026*

[9] (46 pupils declared an interest in these activities, 24 did not). ANOVA *t*-tests sig. *p=0.012.*

The mean score for attitudes to investigations and practical work was a moderate predictor of attitudes to the physical sciences. It was noted that the mean attitude scores to the physical sciences were higher for the pupils who were not involved in group activities; with one exception, this group included the same pupils who positively enjoyed the 'loner' activities identified as a predictor for pupils' attitudes over all the science modules.

9.7.2 Predictors for attitudes at the end of Year 6

There were no predictors from the parental data for the pupils' attitudes over all the science topics (excluding the 'materials' topic) in Year 6; the main predictors at this stage were the pupils' mean attitude score over all the science topics (except the 'materials') studied during the previous year and the pupils' liking for science topics relative to other topics (see Table 9.5).

The regression equations was as follows:

'sciav6ad' = 1.212 + 0.462 x 'sciliks6' + 0.239 x 'sciavad5'

The multiple R was *0.556 (p=0.0001)* and the adjusted R^2 was *0.287* (accounting for approximately 29% of the variance in scores).

*Table 9.5: Attitudes over all science topics (except 'materials') in Year 6 **'sciav6ad'***

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
*Liking for science topics compared with other topics studied in Year 6 (**'sciliks6'**)*	*0.462*	*0.001*
*Mean attitude score to science topics (except 'materials') in Year 5 (**'sciavad5'**)*	*0.239*	*0.028*

For the physical sciences in Year 6, liking for science topics compared with other topics was the major predictor together with gender (the boys having a higher mean score than the girls – see Chapter 5.1). The level of the fathers' mutual involvement in 'tinkering' was also a minor predictor of the pupils' attitudes to the physical sciences (Table 9.6).

The regression equation was:

'physav6a' = 2.530 + 0.446 x 'sciliks6' + -0.269 x gender + 0.211 x 'mtinkstr'

The multiple R was *0.587 (p=0.0001)* and the adjusted R^2 was *0.313* (accounting for approximately 31% of the variance in scores).

*Table 9.6: Attitudes to physical science topics (except 'materials') in Year 6 '**physav6a**'*

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
*Liking for science topics compared with other topics studied in Year 6 (**'sciliks6'**)*	*0.446*	*0.001*
Gender	*-0.269*	*0.011*
*Level of fathers' involvement in mutual 'tinkering' activities (**'mtinkstr'**)*	*0.211*	*0.047*

9.7.3 Predictors at the end of Year 7

By the end of Year 7, the level of the fathers' science education was a minor predictor of the pupils' attitudes over all the science modules, together with pupils' positive attitudes to investigations and the perceived quality of the pupils' relationship with the science teacher(s). The major predictor was the pupils' perceived performance in science together. (Table 9.7).

The multiple regression equation was:

'sciave7' = 0.436 + 0.478 x 'sciperf' + 0.282 x 'invest 7'

+ 0.236 x 'scirel7' + 0.186 x 'mstuleng'

The multiple R was *0.770 (p=0.0001)* and adjusted R^2 was *0.564* (accounting for approximately 56% of the variance in scores).

*Table 9.7: Attitudes to all science modules in Year 7 (**'sciave7'**)*

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
*Perceived performance in science (**'sciperf'**)*	*0.478*	*0.001*
*Liking for investigations/practical work (**'invest 7'**)*	*0.282*	*0.004*
*Perceived quality of relationship with science teacher(s) (**'scirel7'**)*	*0.236*	*0.012*
*Level of father's science education (**'mstuleng'**)*	*0.186*	*0.035*

The fathers' attitudes to their own secondary science education were minor predictors of the Year 7 pupils' attitudes to the physical science modules (Table 9.8). The main predictor was the pupils' perceived performance in science; the pupils' perceived relationship with their science teacher(s) and their mean attitude score over all science topics[10] in the previous year were minor predictors. The importance of good attitudes to science at the end of the primary phase in establishing positive attitudes to school science, particularly the physical sciences, in Year 7 cannot, therefore, be ignored.

The multiple regression equation was:

'physave7' = -0.485 + 0.501 x 'sciperf' + 0.318 x 'scirel7'

+ 0.263 x 'sciav6a' + 0.226 x 'mstuleng'

The multiple R was *0.837 (p= 0.0001)* and the adjusted R^2 was *0.673* (accounting for approximately 67% of the variance in scores).

[10] except the 'materials' topic

Table 9.8: Attitudes to the physical science modules in Year 7('physave7')

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
Perceived performance in science ***('sciperf')***	*0.501*	*0.001*
Perceived quality of relationship with science teacher(s) ***('scirel7')***	*0.318*	*0.001*
Mean attitude score over all science modules (except the 'materials' topic) in Year 6 ***('sciav6a')***	*0.263*	*0.001*
Fathers' attitudes to their secondary science education ***('mstuleng')***	*0.226*	*0.006*

9.7.4 Predictors at the end of Year 8

By the end of the study, the parental factors were no longer predictors of the pupils' attitudes to science (over all the science modules studied during that year); the main predictors were still the pupils' perceptions of their performance in science and their attitudes over all the science modules the previous year (Year 7). Holding the view that science in Year 8 was more interesting than in Year 7 was also important (Table 9.9).

The regression equation was:

'sciave8' = 0.454 + 0.390 x 'sciperf8' + 0.329 x 'sciave7' + 0.238 x 'inter78'

*Table 9.9: Attitudes to all science modules in Year 8 (**'sciave8'**)*

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
*Perceived performance in science in Year 8 (**'sciperf8'**)*	*0.390*	*0.001*
*Mean attitude score (over all science modules) in Year 7 (**'sciave7'**)*	*0.329*	*0.002*
*Holding the view that science in Year 8 science is more interesting than in Year 7 (**'inter78'**)*	*0.238*	*0.019*

The Multiple R was *0.695 (p= 0.0001)* and the adjusted R^2 was *0.457* (accounting for approximately 46% of the variance in scores).

For the pupils' attitudes to the *physical* sciences, there was still some predictive effect of the father's help with outside activities (in Year 5) but the main predictors were gender (the boys' having significantly higher mean attitude scores than the girls), the degree to which the pupils' perceived that some new material had been introduced during the year and also the pupils' perceptions of their performance in science. A positive attitude to the physical sciences at the end of Year 6 was also a minor predictor (Table 9.10).

The regression equation was:

'physciav8' = 0.324 + -0.323 x gender + 0.285 x 'new8' + 0.263 x 'helpdad' + 0.255 'perf8' + 0.223 'physav6a'

*Table 9.10: Attitudes to physical science modules in Year 8 (**'physciav8'**)*

Contributory variable	***Standardised coefficients (beta weight)***	***Significance***
Gender (being male)	*-0.323*	*0.001*
*Perceptions that 'new' material is being covered in Year 8 (**'new8'**)*	*0.285*	*0.001*
*Help from father (reported during Year 5) in out-of-school activities (**'helpdad'**)*	*0.263*	*0.001*
*Perceived performance in science in Year 8 (**'perf8'**)*	*0.255*	*0.005*
*Mean attitude to physical sciences topics (except 'materials') in Year 6 (**'physav6a'**)*	*0.223*	*0.011*

The Multiple R was *0.780 (p=0.0001)* and the adjusted R^2 was *0.579* (accounting for approximately 65% of the variance in scores)

The outcome of the final analyses of the parental data, together with the multiple regression analyses summarised above, are discussed in more detail in Chapter 10. Where appropriate, the findings are compared with those of other research published in the literature.

Chapter Nine: Parental and "home-based" factors and attitudes to school science

9.8 Summary

One of the additional objectives of this longitudinal study was to examine the nature and strength of any links between parental experiences of, and attitudes towards, science and various measures of the pupils' attitudes towards the subject area. This Chapter examined some of these "out-of-school", home-based factors and their possible links with the pupils' attitudes.

Fewer mothers than fathers could re-call details of their primary science education but, for both male and female parents, the overall impression seemed to have been quite favourable. There were no significant correlations between maternal, or paternal, attitudes to primary science (or to investigative work in primary school) and various measures of the pupils' attitudes to science in Years 6 to 8.

Parental re-call of secondary science was better than that of primary science (the fathers' scores being generally more positive than those of the mothers') but no significant correlations were detected between the mothers', or fathers', attitudes to their secondary science education and various measures of their children's attitudes to science in Years 6 to 8. For both mothers and fathers, however, positive correlations were detected between their attitudes to secondary science and attitudes to primary science.

The majority of mothers preferred biology whereas the majority of the fathers preferred physics. No statistically significant relationships were detected between the mothers', or fathers', preferences for biology, chemistry or physics and their child's attitudes to those subjects in Year 8.

There were no significant correlations between the length of either the mothers', or the fathers', science education and various measures of the pupils' attitudes to science. There were, however, statistically significant correlations between the length of the mothers', and fathers', science education and their attitudes to primary or secondary science and a suggestion of a possible relationship between the length of the fathers' science education and the pupils' attitudes to science over all modules in Year 7.

More than twice as many fathers as mothers reported that they enjoyed 'tinkering' (exploring and investigating things) during their secondary school years but there were no significant associations between the parental enjoyment of 'tinkering' and the pupils' attitudes to investigations in Years 7 and 8.

The pupils' perception of 'help' from parents and the parents' perceptions of their involvement with their children in 'tinkering' activities were not necessarily the same but fathers were still generally the prime 'tinkerers' and they were more likely to get involved with their sons, rather than their daughters, in 'tinkering' activities.

Apart from a slight bias towards domestic and culinary activities (at the expense of some of the more 'male' activities) the range of activities pursued by the mothers, together with their daughters or sons, were generally the same as those recorded by the fathers and their children. There were no correlations between either the fathers', or the mothers', combined score (for 'tinkering' and 'encouraging the pupils' interest in science') and the pupils' scores for investigations during any of the 4 years of the study or between these combined scores and various other measures of pupils' attitudes to science in Years 6 to 8.

When the qualitative data were re-classified into *levels* of mutual tinkering, no correlations were found between the mothers' *level* of 'tinkering' and various measures of the pupils' attitudes to science in Years 5 to 8. However there was a suggestion of a weak correlation between the *level* of fathers' tinkering and some of the measures of pupils' attitudes to science in Years 6, 7 and 8.

An association was also suggested between the mothers' perceptions that they were involved in activities which would encourage their child's interest in science and the length of the mothers' science education but data were not available on the various sociological and economic variables which could contribute to this association. A similar association was suggested between the fathers' reported involvement in such activities and the paternal level of science education and there was an apparent gender bias, towards their sons, in the fathers' (self-reported) scores for joint science-orientated activities This bias of fathers towards their sons was supported by the data on parental involvement in 'tinkering'.

In this small-scale study, relatively few parents had continued to study science beyond 16 and few statistically significant correlations/associations were detected between the parents' backgrounds in science and their sons/daughters attitudes to science. However, the qualitative data, provided some suggestions that certain gender-biased tendencies e.g. the fathers' greater involvement in 'tinkering' activities with their sons (rather than their daughters) were still current.

The outcome of multiple regression procedures (using the parental data together with the pupils data generated in Years 5 to 8) to examine the combination of predictor variables which, each year, would best predict the pupils' attitudes to science over all the science topics/modules[11] (and specifically to the physical sciences) were reported. Further discussion is included in Chapter 10.

[11] excluding the 'materials' topic in Years 5 and 6

Chapter Ten: Discussion of findings

Introduction

Before the National Curriculum (Chapter 2) was in place, the research literature suggested that attitudes to science, particularly those of girls, deteriorated as pupils progressed from primary school to the 'option choices' stage of secondary schooling. At that point (about age 14), a decision would be made, whether or not to proceed with further study of the sciences. The general consensus (see Chapter 3) was that the physical sciences were seen as 'difficult' and held less attraction, particularly for girls, than the biological sciences. It was anticipated that the new, compulsory (to age 16) National Curriculum for Science introduced in the early 1990s would, *inter alia,* encourage both boys and girls to adopt more positive attitudes towards the subject and to consider studying the sciences beyond the end of compulsory schooling.

In order to fulfil the research objectives (Chapter 4), the fieldwork focussed, with particular reference to gender, on the examination of pupils' attitudes (between Years 5 and 8)[1] to the physical and biological sciences (Chapter 5). Other "in-school" factors related to the pupils' science lessons and their subject preferences were also examined (Chapters 6 and 7) as well as their pupils' interests and activities in both primary and secondary phases (Chapter 8).

As a supplementary investigation, data were collected from the pupils' parents in an attempt to compare some of the parental attitudes towards, and experiences of, science (including an assessment of their involvement in various "out-of-school" and home-based activities e.g. 'tinkering') with some measures of their children's attitudes to various aspects of science (Chapter 9).

[1] An opportunity was later provided to extend into Year 9 the data collection on some specific issues.

10.1 "In school" factors: The physical and biological sciences with reference to gender (Chapter 5)

The responses suggested that the pupils' favourite topic in Year 5 was 'Space'. 'Electricity & Magnetism'[2] and, to a lesser extent, 'Living things' were the most popular in Year 6. By Year 7, 'Space' was again the favourite followed by 'Electricity & Magnetism' and 'Processes of Life'. No statistically significant annual changes in the mean attitude scores for the topics/modules were detected.

The gender differences, in favour of the boys, in attitudes towards the *individual* physical science modules were only statistically significant for the Electricity & Magnetism topics in Years 6 and 7 and for the Forces module in Year 7. During the early stages of data analysis it became clear, however, that some of the gender comparisons between the primary pupils' attitudes to the individual topics were unreliable because of the lack of consistency in the type, and number, of topics covered in the three different primary schools; many of the group sizes were also very small.

There is little reference in the literature to primary pupils' attitudes to *individual* topics within the physical and biological sciences but, in this longitudinal study, the boys' preferences were clearly for physical science topics, particularly "Space"; this suggested little change from earlier findings such as those of Koelsche and Newberry (1971), Bradley and Hutchings (1973), Kelly (1986) and, more recently, the observations of Murphy and Beggs (2003) in Northern Ireland.

10.1.1 The physical sciences

Despite the slight fall in the boys' mean attitude scores for the physical sciences[3] during Year 6 (see Chapter 5.1) the higher score reported on transfer to Year 7 was further increased (above the Year 5 level), by the end of Year 8. For the girls, the significant decline in attitudes to the physical sciences in Year 6 was also reversed on transfer but the improvement was not maintained and, by the end of Year 8, there was a slight fall in the mean attitude score. From Year 6 onwards, a significant gender difference (in favour of the boys) was, therefore, demonstrated in the mean attitude scores for the physical sciences.

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[2] 'Space' was not studied in Year 6.

[3] Attitudes to the physical sciences are generally regarded as a good reflection of pupils' overall attitudes to science (Ormerod and Duckworth, 1975 and Kelly, 1986). The pattern was reflected by that of the boys' mean attitude score over all modules.

For both the chemistry and the physics modules[4] (which together made up the physical sciences category) there were significant gender differences, in favour of the boys, in the mean attitude scores (see Appendices 5.6 and 5.5).

The gender differences in attitudes to the physical sciences demonstrated in this study showed little change from the overall patterns described in the studies reported by Smail (1984a), Department of Education and Science (1986), Kelly (1986) and earlier researchers (see Chapter 3.3). The boys' fairly positive attitudes to the physical sciences in Year 8 are, however, reassuring in view of the more recent comments of Galton et al. (2002).

By Year 8, the pupils' mean attitude score to the physical sciences showed a good correlation[5] with their current interest in science lessons (and a moderate correlation with the pupils' Key Stage 3 levels awarded in 1999).

10.1.2 The biological sciences

The **biological science** modules (Chapter 5.2) were classified into two components: plant biology and animal (including human) biology so as to enable an exploration of the pupils' attitudes towards each of these particular branches of biology.

Keys (1987) reported no differences between the attitudes of 10-year-olds to the physical and biological sciences. In this longitudinal study, the boys showed relatively little enthusiasm even in Year 5 for the biological sciences and their mean attitude to the biological sciences score fell each year from Year 5 onwards. Although the girls demonstrated a preference[6] for the biological, rather than the physical, sciences at the end of Year 5 their mean attitude score also fell each year from Year 6 onwards and, at the end of both Years 6 and 7, the differences between their mean attitude scores to the biological, and physical sciences, were statistically significant. This contrasts with Kelly's (1986) observations (see Appendix 3.1) that, whilst the gender differences did not change significantly over the period of the G.I.S.T. study, interest in (human) biology and nature study *increased* significantly among *both* sexes, but particularly with the girls, from Years 7 to 9.

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[4] At the end of Year 8, data were collected on the pupils' attitudes to the three *groups* of modules (biology, chemistry and physics).

[5] Correlations between the mean score for the physical sciences in Years 5 to 8 and other measures of attitudes to science are discussed in Chapter 5.1 and summarised in Appendix 6.1.

[6] derived from only two schools *(n=56)*

In Years 5 and 6, the cohort boys' mean attitude scores for the biological sciences had been lower than those for the physical sciences but, by the end of Year 7, the difference was statistically significant. By the end of Year 8 the gap had widened even further.

There was a barely significant gender difference[7], in favour of the girls, in the attitudes to the biological sciences in Year 5 but, by Year 6, the difference was not statistically significant. The gender difference in favour of the girls continued through Years 7 and 8 as the boys' scores, particularly to the 'ecosystems' module in Year 7, became increasingly more negative. The boys' negative attitudes to plant science had also been noted in the data for School XL (the only school to pursue a separate 'Plants' topic in Year 5), where a gender bias in favour of the girls had been suggested for the Year 5 pupils *(n=45)*. Between Years 5 to 8, there was a statistically significant annual deterioration in the boys' enthusiasm for plant biology and the mean biological sciences score[8] at this single school reflected a significant gender difference in favour of the girls.

A decline in enthusiasm, by both sexes, for the biological sciences seemed to have occurred *before* transfer and, by the end of Year 6, it appeared that (in agreement with Smail, 1984a), the boys' and girls' preferences for the physical and biological sciences respectively had been established. After transfer, the gap between the girls' attitudes to the biological and physical sciences widened and the boys demonstrated significantly more positive attitudes to the physical sciences. The early preference by the boys for the physical sciences, and the difficulty of sustaining boys' interest in the biological sciences, was noted by Bradley and Hutchins (1973), Ormerod and Duckworth (1975) and by Kelly (1986) – see Chapter 3.3.

The girls' preferences for biology, compared with the physical sciences, are well documented in the pre-National Curriculum literature (see Chapter 3.3) and little seems to have changed; some of Ormerod's (1975b) comments on reverse polarisation may offer some explanation.

Kelly (1986) suggested that, whilst the girls' enthusiasm for science as a whole was high on entry to secondary school, the decline in enthusiasm by the end of the study was in line with the girls' lack of curiosity for the physical sciences; this could be explained, at least

[7] data from Schools OL and XL only.
[8] average of 'plants' and 'human body' topics ("humplant")

in part, by the complexity of chemistry and physics which had a negative effect on the girls' attitudes.

> "Physical science appears to be seen as a key element of science, yet science lessons do not in general waken an interest in it if this is not present when the children enter secondary school"
>
> (Kelly, 1986, p. 411).

Kelly's comments supported earlier research by Duckworth and Entwistle (1974a) and Keys (1978a) – see Chapter 3.2.1(iv). Keys (1987) noted that girls were more likely than boys to regard the physical sciences (especially physics) as difficult and that girls were more likely than boys to give up studying difficult subjects.

10.1.3 Overall attitudes to science modules

In this longitudinal study, one of the main objectives was to assess the pupils' attitudes to the separate categories of the biological and physical sciences. In order to derive comparable figures which might be compared with other data which referred only to 'science' (without further explanation), the annual mean attitude to science score (over all topics/modules) for each pupil was derived by averaging the scores[9] for each of the science-based topics/modules studied during each year of the study.

For these mean attitude to science scores, there was a highly significant drop between Years 5 and 6 followed by a significant rise at the end of Year 7. The mean score at the end of Year 7, lower than that at the end of Year 5, then remained at approximately the same level during Year 8. This apparent trend in mean scores disguised, however, the very different responses by the boys and girls to the biological and physical sciences which were revealed in the earlier analyses (see Chapter 5).

The girls' mean science score, higher than that of the boys in Year 5, fell significantly between Years 5 and 6 (due mainly to the girls' increasingly negative attitudes towards the physical sciences modules) but neither the rise in the girls' mean score after transfer, nor the subsequent fall in their mean score between Years 7 and 8, were statistically significant. The decline in the girls' mean attitude scores after Year 7, particularly the mean physical sciences score, was in agreement with the findings of Hewison (1982) and

[9] In Years 5 and 6, the scores for the 'materials' topic were removed from the analyses (see Chapter 5.1).

the GIST project (Kelly, 1986). Kelly also observed that the pupils' gender and initial attitude to science were strongly related to their attitudes[10] to science some 3 years later. By the end of Year 6, the boys' mean science score had also dropped slightly from its Year 5 level but, after transfer, the scores exceeded the Year 5 level and there was a further increase in the score in Year 8 (due mainly to the increasingly positive attitudes towards the physical sciences). Only in Year 8 was a significant gender difference, in favour of the boys, detected in the mean attitude to science scores. This was explained by the widening gap between the boys' and girls' attitudes to the physical sciences. The boys' lessening enthusiasm for the biological sciences was not as significant as the girls' increasingly negative attitudes towards the physical sciences (see Chapter 5.3). This showed some similarities with the findings of the G.I.S.T. study (Kelly, 1986) where the difference between the boys' and the girls' (age 11/12) personal liking for science was small but, during the following 18 months, the gap widened as the girls' scores decreased more rapidly than those of the boys.

The improvement in the boys' score in Year 8 differs from the recent observations of Miller et al. (1999)[11] and Galton et al. (2002) who noted a 'dip' in *both* boys' and girls' attitudes at the end of Year 8. There were steep decreases in attitude scores between Years 7 and 8 and between Years 9 and 10 with the boys' scores decreasing less steeply than those of the girls.

In each of the four years of this longitudinal study, there were weak or moderate correlations between the mean attitude scores over all the science topics/modules and other measures[12] of the pupils' attitudes to science (Appendix 6.1); these correlations were in general agreement with the correlations between the mean score for attitudes towards the *physical* sciences and these other measures. This is not surprising since Ormerod and Duckworth (1975) and Kelly (1986) considered that attitudes to the physical sciences may be the best measures of attitudes to science as a whole.

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[10] particularly those of the non-potential scientists

[11] In this cross-sectional study, there was a statistically significant difference in both boys' and girls' overall attitude scores to science between Years 7 and 11 but a significant gender difference, in favour of the boys, in the composite score for overall attitudes to science was only detected in Year 9.

[12] e.g. in Year 7, measures of pupils' interest in science, attitudes to asking questions of the teacher, perceived relationship with the teacher, perceived performance in science and attitudes to investigations.

10.2 "In school" factors: specific aspects of science lessons

Some of the other "in-school" factors which might be linked with pupils' attitudes to science were identified from the literature review (Chapter 3.2) and were discussed in Chapter 6.

These factors could be grouped into three main themes:

1. Issues related to the content and delivery of the lessons particularly the
   - i) pupils' interest in science lessons
   - ii) perceived repetition of content
   - iii) quality of the relationship with the science teacher(s)
   - iv) amount of writing and note-taking in science
2. Pupils' perceptions about
   - i) the difficulty of science
   - ii) their own performance in science
3. Pupils' attitudes to investigations and practical work

The pupils' responses to these separate issues were first examined separately with respect to gender. Correlations were then carried out between the attitude scores for these variables and the pupils' mean attitude scores to the biological, and the physical, sciences in each of the four years. At the end of the study, those variables which had shown moderate, or good, correlations with the measures of the pupils' attitudes to science (over all modules) and measures of the pupils' attitudes to the physical sciences were entered as possible predictor variables, together with some of the parental variables, in the multiple regression procedures (see Chapter 9).

10.2.1 Perceptions of difficulty and performance (see Chapter 3.2.1(iv))

10.2.1(i) *Perceptions of difficulty*

In Year 6 (the first point at which this issue was raised on the questionnaire), a rather low percentage of pupils (21%) found science 'very easy' or 'quite easy' but no significant gender difference was detected. Reporting on the responses of pupils to the Facility of Science scale[13] in the Second International Mathematics and Science Study, Keys (1987, p.121) also failed to detect any gender difference in their responses to this issue but approximately half of the 14-year-olds (compared with about one-third of the 10-year-

[13] This scale also included items concerned with interest and enjoyment, as well as the difficulty, of science.

olds[14]) agreed with the statements 'Science is a difficult subject' and 'there are too many facts to learn in science'.

Comments were, however, made by a few pupils on the perceived *lack of challenge* in science lessons (see Appendix 6.2) and the later research of Osborne and Collins (2000) also noted that, for those Year 11 pupils who intended to continue with science subjects, science was seen as an 'academic' subject the challenge of which appealed to them:

> "you can't just memorise it, you have to understand it"
>
> (Girl, GS3/305, in 'science' group)

The reported difficulty of science did not seem to be a major negative influence on the Year 6 pupils' liking for science, there were moderate, positive correlations between the two measures.

Although, pre-transfer, several of the pupils had expected secondary science lessons to be 'harder', this did not seem to be a cause for concern for the majority of pupils. By Year 7, the five comments made on the difficulty of science were all made by girls (Chapter 6.1.2) – the boys did not admit to having any difficulties. More recently, Pell and Jarvis (2001) observed strong negative correlations between the girls' enthusiasm for science and its perceived difficulty but a similar relationship was not detected for the boys. Although there was some difference in the presentation[15] of the Year 6 and Year 8 questions on difficulty, by Year 8 fewer pupils reported a perceived difficulty with the subject.

Twenty-two per cent of the Year 8 pupils responding to the question admitted that science was difficult to understand. In contrast to Keys' (1987) observations (in which about half of the 14-year-olds perceived science as difficult), this longitudinal study did not reveal any significant gender difference in the mean scores (although it was noted that a higher percentage of boys, than girls, *disagreed* with the statement: "Science is difficult to understand" and a higher percentage of girls *agreed* with the statement). Only a very few pupils made comments which linked lack of understanding to the perceived difficulty of the subject but there were weak, negative correlations between agreement with the statement and perceived performance in Year 8.

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[14] In the Third International study carried out in 1995, 46% of the Year 5 pupils agreed that 'science was an easy subject' (Keys et al., 1997, p.84).

[15] The Year 8 questionnaire sought agreement, or otherwise, with the statement 'Science is difficult to understand'.

About half of the 14-year-olds participating in the Second International Science Study (Keys, 1987, p.120) agreed with the statement 'science is a difficult subject' but this was a composite score including agreement with such statements as 'there are too many facts to learn in science'. There was a significant gender difference in the responses with more girls than boys agreeing with the statement. This is in line with the findings of Kelly (1986) who noted that the complexity of physics and chemistry often had a discouraging effect on the girls. The perceived difficulty of science also attracted many comments in Osborne and Collin's (2000) study. Although the pupils often regarded science as 'common sense' and relatively undemanding up to Year 9, at this point the increased degree of difficulty made the subject uninteresting for some pupils who then became resigned to being awarded poor grades.

When the fieldwork for this longitudinal study was extended to cover Year 9, there was a suggestion that the Chemical Patterns module was the most difficult for both girls and boys to understand and the physics modules were perceived as difficult by a greater percentage of girls than boys. For 14-year-olds, Keys (1987, p.67) reported that chemistry was seen as the most difficult, and physics was regarded as the easiest, branch of science.

The findings of the research study would suggest that, compared with the girls, the boys were, in general, finding science less difficult or, possibly, they were less prepared to report their difficulties. A possible explanation for the boys' lack of comment on perceived difficulty was offered in an American longitudinal study (Riesz et al., 1994). In Riestz's study, the girls attributed their low marks to the difficulty of science – the boys thought that science was not particularly difficult and their low marks were due mainly to poor study skills. The lower percentage of boys, compared with girls, reporting a difficulty with science was confirmed more recently by Miller et al. (1999) who found that there was a significant gender difference, in favour of the boys, in the percentage agreeing with the statement 'science is easy for me'.

Suggestions have recently been made (Pell and Jarvis, 2001) that, for some pupils, who perceive science to be getting *less* difficult, the interest and enthusiasm for the subject may decrease. Explanations suggested by Galton et al. (2002) for the 'dip' in pupils' attitudes in Year 8 included 'boredom' with the work on offer and the possible demotivation of some pupils because of repetition in the work, lack of 'challenge' or a feeling that school work was 'just about tests'.

Osborne and Collins (2000) noted that, for the 'science' group, their desire to continue with science was closely linked to the element of personal challenge:

> "it's got to be challenging, you can't have something that's really easy that you can do first time......"[16]

This favourable view of the 'challenge' element as seen by the pupils was linked, not surprisingly, to their level of achievement. For the girls particularly, it seemed to have a confidence-boosting effect which, in turn, stimulated their interest:

> "....because if you think you're good at it you get the confidence and you start thinking maybe I could be a doctor or something in that field, a scientist or something."[17]

10.2.1 (ii) *Perceived performance in science* *(Chapter 3.2.1 (iii))*

No attempts were to be made in this study to link perceived, and actual, performance in science but, in Years 7 and 8, the pupils were asked about their perceived *performance* in science in order to examine any gender differences. In Year 7, the pupils' mean score for perceived performance in science showed a moderate, positive correlation with the mean attitude score to science (over all modules). The boys had a higher mean score (i.e. they were more positive about their performance) than the girls but the gender difference in mean scores was not significant; the boys also seemed to be more reluctant than the girls to admit to problems of difficulty in science. It was not possible to substantiate whether the boys' comments in these circumstances were in fact exaggerated but, using the pupils' KS3 levels at the end of Year 9, there was a slightly stronger correlation between the boys' perceptions of performance and their KS3 levels than was detected for the girls.

There were also weak correlations between the pupils' perceptions of their performance in science and various aspects of the relationship with their science teacher (see Chapter 6) suggesting that there was some association between the quality of the pupil-teacher relationship and how well the pupils thought they were progressing in science.

By Year 8, a weak negative correlation was suggested between perceived *difficulty* and perceived *performance*. The girls', compared with the boys, perceived science to be more difficult (see 10.2.1 (i)) and the gender difference became statistically significant. The boys seemed to be more positive about their performance than the girls and it was possible that

[16] 'Jake' boys 'science' group
[17] 'Nazim' girls 'science' group

the boys were more reluctant than the girls to admit to any difficulties. These findings cannot, however, be directly compared with those of Keys (1987) - see Chapter 3.2.1(iii) - as actual performance data (other than KS3 levels awarded in May 1999) were not available. Using these KS3 levels, however, the boys' scores showed a good correlation *(r=0.515, p=0.004)* between their perceptions of performance at the end of Year 8 and the KS3 level awarded in Year 9; for the girls, the correlation between the two measures was slightly weaker *(r=0.421, p=0.006).*

10.2.2 Issues related to the content and delivery of the lessons (Chapter 3.2.1)

In the research literature, questions seeking to assess the pupils' 'enjoyment of', or a 'liking for', science are often included within a single construct aimed at expressing the pupils' 'interest' in science. Harris et al. (1997, p.84) noted that 81% of the Year 5 pupils in England had positive attitudes to science (liked it a lot/liked it) and 79% *strongly agreed, or agreed*, with the statement "I enjoy learning science."

Smail and Kelly (1984b) noted that, with younger children, 'attitudes to science' have usually been reported from the topics in which they have reported an interest rather than from sub-scales measuring specific aspects of attitudes e.g. their expectations of success in science (or similar). Data were not, therefore, collected for 'interest in science' as such in Year 5 and attitudes to the specific topics were sought as discussed in Chapter 5.

10.2.2(i) Pupils' interest in science lessons

In each of the Years 6 to 9[18] the pupils were asked how their interest in science lessons had compared with that in the previous year. No significant gender differences were demonstrated in either the Year 6 or Year 7 mean scores but, by Year 8, the percentage of boys (62%) who thought that science was more interesting than in Year 7 was more than twice that of the girls (29%). In Year 8, there was a significant gender difference, in favour of the boys, for responses to the statement 'science is interesting'. In response to the statement 'science is boring', the boys compared with the girls, showed significantly greater disagreement. with the statement.

Although in Year 9 there appeared to be a slight improvement, compared with Year 8, in the girls' interest in science lessons, there was still a significant gender difference, in favour of the boys. It appeared that, while the girls found the biology modules most 'interesting', the boys demonstrated a distinct lack of interest for the 'ecosystems' module.

[18] data from extension to the original study

This was in agreement with the attitudinal responses demonstrated elsewhere in the study (see 10.1.2) which suggested that the boys' attitudes to biology, particularly plant biology, continued to decline from Year 5 onwards. The girls held more negative attitudes than the boys to the physical science modules and this also supports the conclusions drawn from the attitudinal data for the individual science modules.

For both boys and girls there was an increasing interest in science lessons on transfer to secondary school (see Chapter 6.3.2), the boys' and girls' scores for interest in science lessons being approximately the same. In Year 7, the pupils' interest in science compared with Year 6, showed a moderate correlation with the mean score to the physical sciences and a good correlation with the pupils' attitudes to investigations.

In Year 8, interest in science compared with Year 7, was positively correlated with the mean score for the physical sciences, the pupils' perceptions of their performance in science, attitudes to the physics modules and the strength of their agreement/disagreement with the statement that 'we learn something new in science each year'. There was a strong *negative* correlation between the pupils' interest in science and the strength of their agreement/disagreement with the statement that 'science is boring'. There were also moderate correlations with the KS3 levels (assessed in 1999) and with several other measures (see Appendix 6.1).

There was a moderate correlation between the Year 8 pupils' interest in science scores and their mean attitude to science (over all modules) scores but a deterioration in both the boys' and the girls' interest in science lessons was noted[19] between Years 7 and 8. The boys' interest in science then remained fairly stable to the end of Year 9[20] (and the girls' attitudes improved very slightly). This differs from the trend noted for the mean attitude to science (over all modules) score where the boys' mean scores rose slightly between Years 7 and 8. These apparent discrepancies might have been due to the more specific wording of the questions which facilitated the re-call of the content of the areas studied.

The similarity in the boys' and girls' interest scores on transfer, followed by a dip in interest during the following 18 months, was also noted in the G.I.S.T. study (Kelly, 1986). In the G.I.S.T. study, the pupil's social class (and whether or not the pupil was in an

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[19] A weak negative correlation was detected between the Year 8 pupils' interest in science and the strength of their agreement/disagreement with the statement 'we study the same things in science each year'.
[20] Data from extension of original study to end of Year 9

intervention school) had little apparent effect on the final attitudes but the pupils' gender and initial attitude to science were strongly related to their attitudes to science three years later[21]. At the start of the G.I.S.T. study, the gender difference between the Year 7 pupils' personal liking for science was small but, during the following 18 months, the gap widened as the girls' scores decreased more rapidly than those of the boys.

Osborne and Collins (2000) noted that, for Year 11 pupils, some topics such as astronomy, were referred to as 'amazing' or 'fascinating' and there were comments which suggested that the stimulus for the interest in science sometimes originated outside the classroom. As in the longitudinal study, some discussion on the role of teachers in stimulating pupils' interest in science was not overlooked. Pupils emphasised that their enthusiasm for science was increased by teachers who encouraged them to take an active role in their own learning and by teachers who made lessons 'fun' or who maintained a good humoured atmosphere in the classroom.

10.2.2 (ii) Relationship with science teacher(s) (Chapter 3.2.1(i))

In anticipation that a reasonable number of pupils might declare a positive interest in science, questions were included in Years 7 and 8 which might allow any links to be made between the pupils' interest in science and their relationships with their science teacher. The pupils in these years were often taught by more than one teacher and so attention was focussed on the qualitative comments made by the pupils. No attempt was made to collect data for comparative purposes on the pupils' attitudes to teachers of other subjects.

Several negative comments were made about the science teachers and the only positive comment was made by a Year 7 girl who gave this as the reason for choosing science as her favourite subject. However, the moderate, positive correlations in Year 7 between the mean physical sciences score and the pupils' attitudes to asking questions of their science teacher, the perceived quality of the relationship with their teacher and their perceived performance in science, may support the comments in the literature (Hewison, 1982; Woolnough, 1994 and, more recently, Miller at al., 1999) that good pupil-teacher relationships are important in maintaining positive attitudes towards science.

Although there was no statistically significant difference between the mean attitude scores of the girls or the boys to their teachers in Year 7 or in Year 8, in both years, a greater

[21] The pupil's social class and whether or not the pupil was in an intervention school had little apparent effect on the final attitudes.

percentage of boys than girls recorded positive scores for "getting on well with their teacher" (Year 7) and having a "helpful" science teacher (Year 8). In Year 8, however, there was a moderate correlation between the girls' perceptions of the helpfulness of their science teacher and their mean attitude score to science (over all modules).

10.2.2(iii) Repetition of content

Even by Year 6 a significant number of comments were being made about repetition of content, particularly in the biological sciences, and similar comments were made in Year 7 (see Chapter 6.5). In Year 8 it seemed that the boys were more prepared than the girls to express an opinion. The pupils' responses demonstrated some inconsistency in the interpretation of what was meant by 'new' material and so the quantitative data may not necessarily reflect the intention of the question. However the qualitative comments (Appendix 6.8) suggested that those pupils who noted a degree of 'repetition' in science were generally demonstrating neutral, or negative attitudes[22] to science in general.

There was a moderate, negative correlation between agreement with the statements: 'we study the same things in science each year' and 'we learn new things in science each year' but no statistically significant correlations between either of these responses and the mean attitude scores to the physical sciences, or to science (over all modules) were noted.

The perceived repetition of work, in some cases starting before Year 7 and continuing through to Year 11, was noted by Osborne and Collins (2000) as a major factor contributing to pupils' lack of interest in school science. Although the qualitative data in this longitudinal study, revealed several negative comments on repetition of content, this did not seem to have been a major negative influence in the current study. More recently, the demotivation of some Year 8 pupils because of repetition of work has been noted by Galton et al. (2002).

10.2.2(iv) Writing and note-taking in science (see Chapter 3.2.1(i))

Qualitative information gathered from the questionnaires in the secondary phase demonstrated that the negative comments on the amount of writing and note-taking involved in science were offered mainly by the boys but their comments were often related to the displacement of the preferred practical activities by the writing tasks. Several of the detailed qualitative comments (Appendix 6.9) implied that it was a lack of freedom in the content and style of writing in Year 7 science lessons which distinguished it from 'writing'

[22] as suggested by the mean attitude scores to the physical and biological science modules (see Chapter 5).

in English lessons. Osborne and Collins (2000, p.28) commented that this sort of 'boring writing' which demands little participation from the learner ultimately leads to 'boredom, disenchantment and alienation'. They noted that, as far as writing about science was concerned, the pupils felt very constrained by the subject – there was little freedom to express individual ideas compared with, for example, English where:

> "if you want to write about a flower you can write a poem or something, like that, something creative."[23]
>
> (Osborne and Collins, 2000, p.29).

In Year 8, 73% of the boys and 80% of the girls agreed with the statement: "We have to do a lot of writing in science" but there was no statistically significant gender difference for agreement/disagreement with the statement. It would seem that the girls' perceived preference for writing tasks (see Pell and Jarvis, 2001) was not supported by the finding of the longitudinal study; both boys *and* girls may see report writing, or simple copying of notes, as a negative influence on their attitudes to science. There was a moderate correlation between agreement between this statement and agreement with the statement that 'science is boring' – this may suggest that the writing content of science *does* have some negative effect on attitudes, at least in Year 8.

10.2.3 Attitudes to investigations and practical work (Chapter 3.2.1(ii))

Investigations and practical work were popular with the pupils, particularly the boys, in each year of the study. No statistically significant gender differences were, however, noted between the mean attitude to investigations scores in any of the four years but, by Year 8, twice the percentage of boys, compared with the girls, strongly agreed with the statement: "We should do more practical work in science". The absence of a statistically significant gender bias, particularly in the primary years, also reported by Pell and Jarvis (2001), does not support Kelly's view that at primary level science is regarded as a 'male' subject.

In Years 7 and 8, positive correlations (see Appendix 6.1) were identified between a liking for investigations and other measures (e.g. the mean attitude score for the physical sciences) of the pupils' attitudes to science and this supports suggestions (Keys, 1987, p.107 and Keys, 1997, p.33) that practical work has a positive influence on the pupils' attitudes. However, for the reduced number of cohort pupils *(n=60)* who responded to the

[23] 'Adam' (boys 'non-science' group)

additional questionnaire in Year 9, there was a statistically significant fall between Year 8 and Year 9 in the mean attitude scores to investigations for both the boys and the girls[24].

If these data do reflect a deterioration in pupils' attitudes towards investigations and practical work after Year 8 then it may suggest a need to consider the nature, and purpose, of the practical undertaken particularly at this stage. Woolnough (1997) noted that many students found much of the practical work "unstimulating and unhelpful" and he suggested that the practical work should "be pruned and redirected" to give pupils experience of genuine problem-solving projects (Woolnough, 1997, p.69). In the Osborne and Collins (2000) study, the 'non-science'[25] pupils emphasised the 'fun' element of practical work, particularly when dissection was involved and pupils in all the groups thought that the practical work allowed them to remember things better. There was disappointment throughout all the groups, however, that there had been fewer opportunities for practical work in Years 10 and 11 than in the previous years and Osborne and Collins suggested that this might have been responsible for the "switch off" by the boys in the 'non-science' group after Year 9.

10.3 Attitudes to science compared with other subject areas

Although there is a wealth of literature on gender preferences for the biological and physical sciences, there is relatively little published research (see Chapter 3.2.1) on pupils' attitudes to science compared with other subjects. In the longitudinal study, both the boys and girls in Year 6 rated the humanities topics more highly than the topics studied in science. The multiple regression procedures performed at the end of the data analysis (Chapter 9) suggested that, by the end of Year 6, the pupils' 'rating' of school science against the other subjects on offer was already an important issue.

In the secondary sector information was sought on 'favourite' subject areas rather than on *individual* topics and it was anticipated that a link might be established between a pupil's selection of science as a 'favourite' subject and various measures of their attitudes to science. However, due to the very small number of pupils nominating science as their favourite subject at the end of the study, detailed further analyses[26] were not undertaken.

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[24] Osborne and Collins (2000) also noted that the positive influence of practical work on pupils' attitudes tailed off by Year 10.

[25] pupils who did not intend to continue with science post-16.

[26] some further analyses were, however, undertaken on the data collected for the 10 cohort pupils who decided to study one or more of the sciences post-16 see 10.3.2).

10.3.1 Science and humanities in the primary school: a comparison

An attempt was made to assess overall attitude changes to the humanities topics and to compare the data, with respect to gender, with the mean attitude scores to both the physical and biological science topics in Years 5 and 6.

In neither Year 5 nor Year 6 were there any significant gender differences in the mean attitude scores for the humanities topics. For the boys, there was no significant difference between the mean attitude scores towards the science topics[27] and the humanities topics in Year 5. By Year 6, however, as the popularity of the science topics declined both the boys and the girls demonstrated a highly significant preference for the humanities.

It is interesting to note that, for the Year 5 girls, there was a significant difference between the mean scores in favour of the *science* topics (and the boys preferred the humanities). By Year 6, the girls as well as the boys favoured the humanities. In neither year was there any statistically significant correlation between the mean attitude score to the humanities and any of the measures of attitudes to science.

There was good agreement between the data for the mean attitude scores to science and to the humanities for the cohort pupils *(n=71)* and those for the whole year group *(n=102).* Although pupils' attitudes towards the humanities topics in Year 6 appeared to be significantly more positive than those towards the science topics, the variation in the humanities topics studied at the different schools and the removal (because of the differences in content) of the very unpopular 'materials' topics from the mean attitude to science[28] scores in Years 5 and 6, meant that the detailed comparisons may be subject to inaccuracies. However, for science, the data suggested that the girls' attitudes to science dropped significantly between Years 5 and 6. The girls generally held more extreme attitudes than the boys about science compared with other subject areas but an examination of the pupils' qualitative comments gave relatively little explanation for this (although three girls, but no boys, commented on the perceived difficulty of science).

[27] excluding 'materials' topic

[28] to provide an *adjusted* mean score for the physical sciences and an *adjusted* mean score over all the science modules.

Although practical activities in both science and the humanities were favoured by the pupils, the sense of drama attached to historical events generated enthusiasm (particularly by the boys) for some of the topics in the humanities. Visits (to an Elizabethan manor house) and residential visits to the Isle of Wight were also positive attractions. 'Finding out' about the past was linked with positive attitudes, by both boys and girls, to the humanities. The humanities, as well as the science, topics attracted criticism from some pupils about the amount of writing involved.

In Years 5 and 6, mathematics and P.E. were regarded as 'favourites' by both girls and boys but, because of multiple answers, these could only be considered as a rough guide to the pupils' preferences. In Year 6, history came a close third (with one vote less than for P.E.); only five pupils included science as a favourite subject area and only three of the pupils (1 boy, 2 girls) demonstrated an interest in "being a scientist". This is in line with the comments of Pollard (1994) who reported that science was one of the least liked areas of the primary curriculum. In a more recent study by Pell and Jarvis (2001), practical science and English were, however, regarded with more enthusiasm than mathematics.

10.3.2 Subject preferences in the secondary school

One of the objectives of the research study was to assess the popularity of science compared with other subjects at secondary level.

By Year 7, a clear preference was shown by the girls for the performing arts and English; Design and Technology was more popular with the boys than with the girls. The preference[29] of the girls for English (as well as the humanities) is in agreement with the findings of Colley et al. (1994). The humanities was the only area where the pupils' positive relationship with the teacher was regularly cited as the main reason for their choice of favourite subject. For mathematics, the qualitative responses suggested a strong link between the choice of mathematics as a favourite subject and the pupils' perceived performance in the subject.

Science had been regarded as a favourite subject by only five pupils in Year 6 and by four pupils in Year 7; by Year 8, only three pupils regarded science as their favourite subject. Some of the anticipated analyses between these pupils' attitude to science scores and other variables encompassed by the study were not, therefore, deemed appropriate.

[29] boys' preferences were for P.E. and science.

However, after the Key Stage 4 examinations (G.C.S.E. Double Award), two of the five students who regarded science as their favourite subject in Year 6 chose to study one or more of the sciences at 'AS' or 'A' level together with 8 boys (but no girls) from the original cohort who stayed at the same comprehensive post-16. Although there was considerable disparity in the group sizes, the data suggested, that the 10 pupils who chose[30] to continue with science post-16 had a significantly higher mean attitude score to the physical sciences at the end of Year 8, as well as a significantly higher mean score for their perceived performance in science in Year 8, compared with their colleagues who did not continue with the study of science post-16.

By Year 8, the popularity of the humanities appeared to decline but the percentage of pupils who regarded English as a favourite subject increased. The gender bias, towards the girls, in the nomination of the performing arts as a favourite subject in Year 7 was maintained in Year 8. Science was only regarded as a 'favourite' subject by very few pupils and this is in line with the research of Hendley (1995, 1996) who found that science was the least liked (out of English, mathematics, science and technology) by KS3 pupils.

10.4 "Out-of-school" factors: activities and interests (Chapter 3.4)

Most of the research on "out-of-school" factors has focussed on their possible relationship to the pupils' achievements in, rather than their attitudes towards, science. One of the objectives of this research was, therefore, to investigate whether there was any relationship between the pupils' choice of extra-curricular activities and interests and their attitudes to school science.

The "out-of-school" activities proved to be very wide-ranging (see Chapter 8). Some activities attracted very few entries, however, and so the pupils' participation in one, or more, *groups* of activities were recorded. ANOVA procedures were then undertaken between the pupils' membership of these groups and various measures of the pupils' attitudes to science.

[30] A significant difference between the mean of the KS3 levels, in favour of the post-16 science students, was also identified.

10.4.1 Pupils' activities and interests in the primary sector

The percentage of Year 5 pupils (80.2%) who indulged in 'sporting activities' and/or 'other outdoor activities' was the same as that (80%) found by Keys (1997). This is reassuring in view of current concern (British Broadcasting Corporation, 2002c, 2003b and Revill, 2002) about the decline in physical activity amongst young children. There was no significant difference, however, in the mean attitudes to science scores for those pupils who participated in sporting activities and those who did not but most of the Year 5 pupils were able to acknowledge the contribution of their "out-of-school" activities to their "in-school" learning.

The mean attitude score over all science modules and the mean physical sciences score (both excluding the score for the 'materials' topic) of those Year 5 pupils who recorded an interest in individual, non-sporting activities (category 1) were significantly higher than those of the pupils who did not record an interest in such activities (see Appendix 8.3). In Years 5 and 6 there was some suggestion that those pupils who enjoyed "out-of-school", 'loner' activities in preference to group activities held more positive attitudes to science than their peers.

In Year 6, no significant difference in mean scores was observed between the pupils in the sporting and non-sporting groups for any of the measures of attitudes to science but, by Year 7, the mean attitude score over all science modules for those pupils who enjoyed individual, non-sporting activities was significantly higher than that of the pupils who did not record an interest in such solitary activities. Although the ages of the children were very different, there is some similarity between the suggestion that the attitudes to science scores were higher for the 'loners' who enjoyed individual (non-sporting) activities and the findings of Woolnough (1991, 1995). Woolnough compared the psychological profile of potential scientists and non-scientists among 'A' level students and noted that the former (who presumably had fairly positive attitudes towards science) were more 'task-centered' than 'person-centered' and were more interested in ideas than in people.

10.4.2 Pupils' activities and interests in the secondary sector

In Year 7, significant gender differences were detected, in favour of the boys, for the mean attitude score to P.E./games (which would have included some "out-of-school" sporting activities) but no statistically significant correlations were detected between the pupils' mean attitude score for P.E. and the various measures of attitudes to science. By Year 8, however, the differences in the attitude measures[31] for those who recorded "out-of-school" sporting activities, and those who did not, were significant.

There was increasing participation in "out-of-school" individual sporting activities between Years 5 to 8 and, between Years 7 and 8, preferences appeared to be fairly stable. In Year 8, the pupils who participated in sport demonstrated significantly higher mean scores for their attitudes to science (over all modules) and for their interest in science compared with pupils who did not participate in "out-of-school" sports but the disparity in the group sizes was considerable and this finding should be interpreted with caution. No significant differences were detected between the responses of the cohort and the non-cohort pupils and this suggests that the cohort pupils were representative of the year group as a whole.

The data generated in this study suggested that the vast majority of pupils experienced a wide-range of "out-of-school" activities during both their primary and secondary years. In this relatively small study, however, very few links could be established between any particular type of activity in which the pupils engaged and various measures of their attitudes towards school science.

10.5 "Out-of-school" factors: parental attitudes, and experiences, of science

One of the additional objectives of this longitudinal study was to examine the nature and strength of any links between parental experiences of, and attitudes towards, science and various measures of the pupils' attitudes towards the subject area (see Chapter 9).

10.5.1 Parental attitudes towards their own primary science education

In this relatively small-scale[32] study, relatively few of the parents had themselves followed science post-16. Their overall impression of science seemed to have been quite favourable although fewer mothers, compared with fathers, could re-call details of their primary science education.

The fathers' mean attitude score for their own primary science education was higher than that of the mothers but there was no significant difference between the mean scores. There

[31] mean attitude to science scores over all science modules and for interest in science

[32] Although the overall response rate was quite good (63%), the removal from the analysis of incomplete pupil data as well as the higher than anticipated loss of pupils to other comprehensives at the end of Year 6, meant that there were only complete data for 71 pupils.

were no significant correlations between maternal, or paternal, attitudes to primary science and various measures of the pupils' attitudes to science over the four-year period. Nor were there any significant correlations between the parental attitudes towards investigations at primary school and the attitudes of their children to investigation work or any other measures of the pupils' attitudes to science.

10.5.2 Parental attitudes towards their own secondary science education

Parental re-call of secondary science was, not surprisingly, better than that of primary science. The mean scores for the mothers' and fathers' attitudes to secondary science were not significantly different but the fathers' attitudes were generally more positive. There were no significant correlations between the mothers' attitudes to their secondary science education and various measures of the pupils' attitudes to science but a weak correlation was suggested between the fathers' attitudes to secondary science and the pupils' attitudes to science (over all modules) in Year 7. For both mothers and fathers, positive correlations were detected between their own attitudes to secondary science and attitudes to primary science.

10.5.3 Parental subject preferences in science

When asked to give a preference for physics, chemistry or biology, the majority of the mothers preferred biology, whereas most of the fathers preferred physics. This gender difference in the parents' attitudes is in line with that recorded in the literature (see Chapter 3.3). No statistically significant relationships were detected between the mothers', or fathers' preferences for biology, chemistry or physics and their children's attitudes to those subjects in Year 8.

10.5.4 Length of parental science education

Thirty-four percent of the mothers (but only 24.4% of the fathers) had given up studying science before age 16 and so, because of the small numbers of parents in each of the four sub-groups, several of the proposed statistical analyses were now likely to be inappropriate or, at best, unreliable.

By the end of Year 7, multiple regression procedures (see Chapter 9) suggested that the level of the fathers' science education was a minor predictor of the pupils' attitudes to science (over all the modules) and the fathers' attitudes to their own secondary science education were predictors of attitudes to the physical science modules. There were no statistically significant correlations between the level of the mothers' science education and various measures of the pupils' attitudes to science. Woolnough's (1994b) study noted that, for 'A'-level pupils, their attitudes to science[33] *were* influenced by the level of the parental study of science but this was a larger scale study and it might be assumed that the pupils in question would already have formed reasonably positive attitudes to the subject area.

10.5.5 Parental involvement in 'tinkering'

No significant associations were detected between the maternal, or paternal, enjoyment of 'tinkering' during their years in secondary education and their children's attitudes to investigations in Years 7 or 8. The data suggested, however, that the pupils' perception of 'help' from parents and the parents' current perceptions of their involvement with their children in 'tinkering' activities were not necessarily the same. The data from this small sample suggested that, generally speaking, fathers were still the prime 'tinkerers'[34] and that they were more likely to get involved with their sons, rather than their daughters, in 'tinkering' activities.

When the re-classified maternal data for current 'tinkering' (which took account of the different *levels* of 'tinkering') were compared with various measures of the pupils' attitudes to science no correlations were found. However, there was a suggestion of a weak correlation between the level of the fathers' involvement in mutual 'tinkering' activities and some of the measures of pupils' attitudes to science in Years 6, 7 and 8 (see Chapter 9.4.3). There were also suggestions of statistically significant associations between both the mothers' and fathers' perceptions that they were involved in activities which would encourage their child's interest in science and the length of the mothers', and fathers' science education.

10.5.6 Parental involvement in other activities with their children

Apart from a slight bias towards domestic and culinary activities (at the expense of some of the more 'male' activities) the range of activities which were pursued by the mothers, together with their daughters or sons, were generally the same as those recorded by the fathers and their children. There was, however, an apparent gender bias, towards their sons, in the fathers' (self-reported) scores for joint science-orientated activities and this is

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[33] Measured on a different basis (the importance of science in getting a job)

[34] There was a weak correlation between the *level* of the fathers' involvement in 'tinkering' (and other science-orientated activities) and some of the measures of pupils' attitudes to science in Years 6 to 8.

in line with the observations of Meyer (1961) who noted the greater influence of the father, compared with the mother, on their child's interest in science.

In this smaller scale research study, there was no correlation between the fathers' combined score (for 'tinkering' and 'encouraging the pupils' interest in science') and the pupils' scores for investigations during any of the 4 years of the study and no other significant correlations were identified between the combined score for 'tinkering'/ 'encouraging science' and the various measures of pupils' attitudes to science in Years 6 to 8.

However, analysis of the "in-school" and "out-of-school" variables using multiple regression procedures suggested that the Year 5 pupils' positive attitudes to science (but not to the humanities) were associated with the maternal involvement in "out-of-school" activities and, by Year 8, the paternal help given (in Year 5) with "out-of-school" activities was a predictor of the pupils' attitudes (to the physical sciences). For the younger pupils, the observed maternal involvement in the pupils' outside interests (and the positive association with the pupils' attitudes to science) was not surprising but many underlying socio-economic factors would have been involved, the details of which were not available to the researcher. For older children, the association between paternal involvement (in, for example, 'tinkering activities') and the pupils' attitudes to science suggested that some of the gender biases reported in the earlier research literature (Clarricoates, 1978; Stanworth, 1981; Skelton, 1989), for example the greater influence of the father, rather than the mother, in possibly encouraging an interest in science in their sons, rather than their daughters, were still prevalent.

10.6 Comment

The associations observed in this longitudinal study need to be interpreted with caution, relatively few parents had continued to study science beyond 16 and quite a high percentage of mothers (34 %) and fathers (24 %) had actually given up science before age 16.

The multiple regression analyses undertaken using the data from both pupils and parents did, however, provide some useful insights about the "in-school" and "out-of-school" variables which may be predictors of the pupils' attitudes to school science over the four years of the study.

The following Chapter provides a summary of the findings of the research, notes some of the study's limitations and suggests how some of the implications might inform future research and practice.

Chapter Eleven: Conclusions

Introduction

A summary of the findings of the longitudinal study with respect to each of the seven research questions raised in Chapter 4, is set out in section 11.1. This section is followed by some comments on the limitations of the study (11.2) and on the implications for future research (11.3).

11.1 Answers to the research questions

The research questions to be answered by the longitudinal study (see Chapter 4) are re-stated below together with a summary of the findings relevant to each of the seven questions.

Question 1: A comparison with the pre-National Curriculum literature

Did pupils who were exposed to the new compulsory curriculum (Chapter2) demonstrate more positive attitudes to various aspects of school science than those reported in the pre-National Curriculum literature (Chapter 3) for pupils in the same age group?

Conclusions

Although there were individual exceptions, the pupils' mean attitude scores (taken over all the science topics) during the four years of the study were recorded as slightly positive. The mean attitude score (*3.8*) in Year 5 fell significantly in Year 6 *(3.2)* and, despite the improvement in interest after transfer to secondary school in Year 7 *(3.3)*, remained at almost the same level in Year 8 (Chapters 5.4.2 and 6.3.3). Although there was an improvement in the boys' attitudes to the physical sciences between Years 7 and 8, the trend in the pupils' attitudes showed little improvement from those reported in the pre-National Curriculum literature.

Question 2: The physical sciences and gender

Compared with pre-National curriculum findings, was there was any improvement in attitudes, particularly those of the girls', to the physical sciences in the early secondary years?

Conclusions

By the end of Year 6, the girls' lack of enthusiasm for the physical sciences was demonstrated. At the end of Year 5, the girls' mean attitude score over all the science topics (physical and biological sciences taken together) was higher than that of the boys but, from Year 6, there was a gender difference throughout the secondary years in favour of the boys (due mainly to the girls' lack of enthusiasm for the physical sciences). This confirms the gender bias noted in the pre-National Curriculum research literature.

Whilst the girls demonstrated negative attitudes to the physical sciences for the duration of the study, it was noted that both the boys' and the girls' mean scores for the biological sciences fell each year from Year 6 onwards, the boys' scores being particularly negative by the end of Year 8. The boys' distinct lack of enthusiasm for biology was perhaps more pronounced than that suggested in the pre-National Curriculum literature.

Question 3: Decreasing interest in school science

If attitudes were not being improved, at what age were pupils losing interest in science and what might be some of the underlying "in-school" reasons for this?

Conclusions

In the primary phase, a decline in interest in science was noted (see Chapter 6.3.9), during Year 6 (age 10-11). Following the increase in interest during Year 7, the 'dip' in interest during Year 8 (age 12-13) was much more pronounced for the girls than for the boys (although a slight recovery was made by the girls during Year 9).

Perceived repetition of content, particularly in Years 6 and 8, was reported by many pupils (Chapter 6.5). Most of the pupils who felt that there was some degree of repetition (with little extension to existing knowledge) in science held neutral, or negative, attitudes to the subject[1]. In Year 8 it seemed that the boys were more prepared than the girls to express an opinion about this.

Although the perceived difficulty of science was mentioned by several pupils, it did not appear to be a significant negative influence on the pupils' attitudes (Chapter 6.1). The pupils' perceptions of their performance were important (Chapter 6.2). It appeared that the boys generally held more positive perceptions about their performance than the girls and that they were less likely than the girls to report any difficulty. Good pupil-teacher relationships were also important in maintaining positive attitudes to science.

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[1] as suggested by the mean attitude scores to the physical and biological science modules (see Chapter 5).

The pupils' negative attitudes to certain science topics, particularly in the biological sciences, were often linked with insufficient practical work. In line with the pre-National Curriculum literature, the pupils' attitudes (particularly those of the boys) were generally enhanced when practical work was on offer but data collected in an extension (to Year 9) of the research study (see Chapter 6.7.6) suggested that the pupils' enthusiasm for investigations and practical work declined by the end of Year 9 (the end of KS3). Report writing, or simple copying of notes, may negatively influence both the boys' and the girls' attitudes to science particularly if it displaces an opportunity for practical work (Chapter 6.6).

Question 4: The popularity of science

How did pupils' attitudes to school science compare with those towards other school subjects?

Conclusions

In Year 5 the girls preferred science whilst the boys preferred the humanities. By Year 6, the relative popularity of the sciences had fallen (both girls and boys preferred the humanities) and only five, out of 71, pupils regarded science as their favourite subject (Chapter 7).

After transfer to secondary school, only four of the pupils regarded science as their favourite subject. For the Year 7 girls, Performing Arts was the most popular subject area; the boys preferred Design and Technology. A significant gender difference in preferences for Design and Technology was noted in Year 7 with almost twice the percentage of boys, compared with girls, recording it as their favourite subject.

By Year 8, the girls showed more enthusiasm than the boys for the performing arts and the number of pupils regarding English as a favourite subject had increased from 6 (5 girls, 1 boy) to 19 (11 girls, 8 boys). By Year 8, only three pupils recorded science as their favourite subject and the humanities also appeared to have declined in popularity. The pupils' qualitative data provided in the study allowed some possible reasons for the popularity of other subjects, particularly in the primary phase, to be suggested (Chapter 7.3.1).

Question 5 : Pupils' "out –of-school" interests and activities

Were there any relationships between the nature of the pupils' "out-of-school" hobbies, activities and interests and the pupils' attitudes to various aspects of school science?

Conclusions

Some observations were made between the type of "out-of-school" interests enjoyed by the secondary pupils and their attitudes to science. There was a suggestion that those pupils who enjoyed individual, non-sporting activities demonstrated more positive attitudes to science than their peers but little statistical significance can be attached to these data.

Question 6: Parental attitudes towards, and experiences of, science

Were there any relationships between parental attitudes towards, and experiences of, science (including parental involvement in home-based activities such as 'tinkering') and the pupils' attitudes to school science?

Conclusions

Apart from a positive correlation between the fathers' attitudes to their secondary science education and the pupils' attitudes to the physical sciences in Year 7, no statistically significant relationships were detected between the parents' attitudes to various aspects of their own science education and the pupils' attitudes to science.

There was a positive link between the length of the mothers' and fathers' science education and the parents' perceptions that they were involved in activities which would encourage their child's interest in science. There was also a positive correlation between the length of the fathers' science education and the Year 7 pupils' mean attitudes to science score over all modules.

No significant associations were detected between the parents' enjoyment of 'tinkering' during their secondary education and their children's attitudes to investigations in their secondary years. Fathers still appeared to be the prime 'tinkerers' and they were more likely to get involved with their sons, rather than their daughters, in joint science-orientated activities including 'tinkering'. There was a weak correlation between the *level* of the fathers' involvement in 'tinkering' (and other science-orientated activities) and some of the measures of pupils' attitudes to science in Years 6 to 8.

Question 7: The relative importance of "in-school" and "out-of-school" factors

Using multiple regression techniques, applied to both the "in-school" and "out-of-school" data, could any predictors of the pupils' attitudes to science at various stages of the study be ascertained?

Conclusions

Using multiple regression techniques, maternal involvement in "out-of-school" activities in Year 5, together with the types of activity enjoyed by the pupils, were predictors of the pupils' attitudes to the science topics. For the physical sciences, a positive attitude to investigations was also a predictor.

By Year 6, the pupils' liking for science topics compared with other topics/subject areas was the main predictor of attitudes to the science topics. For the physical science topics, gender (being male) as well as the level of the fathers' involvement in mutual 'tinkering' activities were predictors of attitudes.

The pupils' perceptions of their performance in science was the main predictor of attitudes in Year 7 as well as the perceived quality of the relationship with their science teacher(s). For the physical sciences, a positive attitude to the science topics in Year 5 as well as the fathers' attitudes to their own secondary science education were also predictors.

At the end of the study, the pupils' perceived performance in science was again the main predictor of attitudes over all the science modules (and specifically the physical science modules) together with a feeling that science lessons in Year 8 were more interesting than in Year 7. An acknowledgement that some 'new' material had been introduced during Year 8 was a predictor for attitudes to the physical sciences, together with the help from fathers (reported in Year 5) in "out-of school" activities, gender (being male) and the pupils' attitudes to the physical sciences at the end of the previous year.

11.2 Limitations of the study

It was originally anticipated (see Chapter 4) that data for over 100 pupils and their parents would be available for analysis. However, by the end of Year 6, the number of pupils for whom parental data were also submitted had fallen and further attrition[2] occurred at the beginning of the secondary phase - by the end of the study, there were only 71 pupils for whom all four years' complete data, together with parental responses, were available.

[2] some relevant data were also available for a number of these pupils in Year 9.

The conclusions drawn from this longitudinal study were therefore based on data provided by a relatively small number of pupils (30 boys, 41 girls) attending three primary schools and, subsequently, the same mixed, comprehensive school (*number on roll = 1200*) within walking distance of the three participating primary schools. All four participating schools drew their pupils from essentially the same socio-economic population in a small town just outside Oxford. Although one of the primary schools (School UN) was Catholic-aided[3], with respect to parental employment levels, family income, ethnicity or ability range of intake, there was little reason to believe that the populations in each of the primary schools differed significantly from each other.

The comprehensive school to which the cohort, and other pupils, transferred could be considered to be generally representative (regarding facilities, intake and socio-economic factors) – but see footnote 3 - of other urban, mixed comprehensive schools in Oxfordshire; in league tables for KS3 and KS4 it was placed just below the average for academic performance in the County's schools.

By the time the fieldwork was initiated, the three primary schools were following the objectives laid out in the National Curriculum but the choice of topics studied each year (see Chapter 5) varied from school to school and this meant that not all pupils in the cohort were studying the same topic in the same school year; in some cases the number of pupils studying a particular topic in the primary phase was very small indeed. Even when the same topic (e.g. 'magnetism and electricity') was on offer in all three primary schools during the same year, there were some variations in the content and delivery of the topic. Where possible, confirmation was sought from the textual analysis of qualitative data from questionnaires and tape-recordings but the small group sizes meant that only tentative conclusions could be drawn from the data.

For the four years of the main research study, the researcher (although introduced to the pupils as a teacher) was not a member of staff at the any of the participating schools. However, it may have been that some of the pupils were reluctant to record their negative attitudes towards various issues, particularly with respect to the quality of the perceived relationships with some (possibly named) teachers or the interest factor of their lessons, lest the researcher convey this information to the teacher(s) concerned. In the event, there

[3] No single explanation can be given for the higher than expected loss of primary pupils, particularly those from the Catholic school, to other secondary schools (state and independent). The loss may have been due to the changing patterns of parental employment in the area and/or the attraction of significant recent capital investment (and hence improved facilities) in another comprehensive school some 4 miles away.

was very little opportunity for contact between the researcher and individual teachers and the pupils were given an assurance that all information given by them would be treated as confidential. The completed questionnaires were all examined, and the data were subsequently processed, off-site.

In the summer of 1998, as the original study was drawing to a close, the researcher was appointed to a teaching post on the staff of the comprehensive school. Towards the end of the next summer term (1999) some additional data on the pupils' attitudes to science were obtained from a questionnaire (Appendix 4.5) designed primarily for "in-school" purposes (see Chapter 4.17). As far as the longitudinal study was concerned, this additional questionnaire focussed mainly on issues associated with the nine different modules which had been taught that year. Little space was available for qualitative comments and, on later examination, none of these comments mentioned any teacher by name. Some of these modules were taught by more than one teacher and any general comments about a teacher's input would not enable that teacher to be identified from the questionnaires alone.

The factual data (i.e. level of education, different sciences studied etc.) supplied by the parents (Appendix 4.8) were assumed to be correct - the information could not be verified within the agreed terms of the study. Because of the possible differences in interpretation, the parents were not asked to quantify *how much* or *how frequently* they were involved with their child in scientific activities and/or 'tinkering' but the *level* of involvement (see Chapter 9.4.3) was assessed from the data by the researcher at a later date. The validity of some of the quantitative analyses to explore any links between parental attitudes towards, and experiences of, science with the various measures of the pupils' own attitudes to school science, was also limited by the fact that, in some categories[4], the number of cases was very small. The qualitative comments provided by the parents proved useful, however, in supporting some of the findings.

Although the effects of variations in teaching style on pupils' attitudes to science had received comment from Hewison (1982), Woolnough (1994c) and, more recently Bricheno (2000), no attempts were made to include such variables in this small scale study – see Chapter 3.2.1(i). The decision not to take into account the possible variation in teaching styles was based, in part, on the inappropriateness of the researcher's assessment of other teachers' professional competence and style of delivery. Most of the pupils in the

[4] For example, relatively few of the parents had studied science beyond age 16.

secondary phase were taught by two or more science teachers and, as three or four classes in a single year would be taught simultaneously, it would have been impossible to monitor teacher variables for all the classes. Also, access to the secondary phase for the purposes of research was conditional on minimum teacher involvement as agreed with the 'gatekeepers' (see Chapter 4.11).

The limitations set out above therefore suggest that caution is necessary in generalising the findings in a wider context. Additional analyses of the quantitative data were, however, conducted to establish that the reduction in group size from the full year *(n=102)* to the final cohort *(n=71)* had not produced any significant differences[5] in the findings of the study (particularly with respect to gender issues). It was noted that the range of qualitative comments was virtually identical for both groups.

In the secondary phase it was possible to compare the attitudes of the cohort pupils with those of pupils from the seven, non-participating primary schools who had also joined the participating comprehensive (see Chapter 4). With one minor exception concerning the performing arts (for which an explanation is offered in Chapter 8), there were no significant differences between the cohort pupils' mean scores for various measures of the pupils' attitudes to science and those of the pupils' who had entered the comprehensive from non-participating primary schools. This suggested that the data from the cohort pupils were fairly representative of the secondary year groups as a whole.

11.3 Implications

It was clear from the responses in the longitudinal study, particularly those provided by the qualitative data, that negative attitudes to certain aspects of school science were still present and that very few pupils regarded science as their favourite subject. Even though the vast majority of pupils are now required to study science up to age 16, the attitudes formed in the middle secondary years will have some influence on post-16 choices. The implications of the findings of this research study therefore remain relatively unchanged from those highlighted in the "Realising our Potential" Report (Cabinet Office, 1993).

[5] The data analyses for the responses of both groups to questions on various aspects of the pupils' attitudes to science and to the humanities are presented in Chapters 5 to 8.

11.3.1 Post-16 uptake of the sciences

The data on 'A' and 'AS'[6] level uptake of the sciences (see Appendix 11.1) demonstrate the general trends in post-16 pupils' attitudes to the three main sciences. Since 2001, post-16 pupils could opt to take one, or more, sciences at the new 'AS' (Advanced Subsidiary) levels as the first part of a 2 year 'A' level course, although not all of these students would necessarily wish to advance, one year later, to the 'A' level examination. The introduction of these one year Advanced Subsidiary levels attempted to give a greater breadth to pupils' post-16 studies and to be a positive move towards increasing the scientific knowledge and skills of young adults who may not necessarily proceed with the study of sciences at tertiary level.

Despite an increase in the percentage uptake in biology by both girls and boys (and, in chemistry[7], by the girls) physics remained relatively unattractive at both 'A' and 'AS' level (Osborne et al., 1998). The increase in the percentage uptakes of biology and chemistry has been attributed (Osborne et al., 1998, p.27) to the uptake of a single science subject (particularly biology) by arts students - the percentage of the 18-year-old cohort selecting at least two of the sciences together with mathematics and/or further mathematics (the traditional choices for students seriously considering a science-orientated career) had in fact fallen.

In all three sciences, the percentage contributions of the 'AS' level entries (1999/2000) were still small when compared with those at 'A' level (Blair, 2003). If one of the objectives for the introduction of the new 'AS' levels was to encourage the study of some science by more post-16 pupils' (Dearing, 1996) then there has, as yet, been little evidence of this.

These concerns about the uptake of post-16 sciences and the effects on the supply of people with science, technology, engineering and mathematical skills were re-inforced in the recent Roberts[8] review (H. M. Treasury, 2002) requested as a result of the Treasury's concern about meeting targets for national economic growth. Whether the percentage increase in the uptake of biology and chemistry at 'A' level will be reflected, in due

[6] These replaced the former Advanced Supplementary level examination (also normally examined after one year in the sixth form).

[7] due to the increased uptake since 1991 of 'A' level chemistry (an additional 2,294 entries) rather than the improved uptake of 'AS' level chemistry (from 424 to 488 entries).

[8] Sir Gareth Roberts, FRS, President of Wolfson College, Oxford and President of the Institute of Physics.

course, by an increase in the proportion of scientifically-orientated graduates taking up, and remaining in, careers in science remains to be seen.

11.3.2 Curriculum issues during the compulsory school years

The management of change, particular with respect to school curricula, is not an easy task. A decade after the inception of the National Curriculum, Anslow (1999) noted:

> "The last ten years......have been characterised by a flurry of time-consuming hand–to-mouth activity, a whirlpool of disruptive and largely unproductive change"
>
> (Anslow, 1999, p.19)

These comments could have been applied to many situations where the introduction of new strategies has met with varying degrees of disapproval. There was certainly a 'flurry' of apparently unco-ordinated activity at the end of the 1980s (see Fowler, 1988 and Moon and Mortimore, 1989) which did not subside once the new Curriculum was in place (Moon, 1991).

This small-scale study suggests that, even at primary school, science is competing for popularity with other subject areas e.g. the humanities. The subject content of a prescriptive school science curriculum may still be offering relatively few attractions compared with the greater variety of content in other centrally-prescribed non-science subjects where the "out-of-school" visits and the opportunities for artwork and 'making and doing' tasks, seemed to provide greater stimulation of interest (see Chapter 10). This has implications for both science teachers and for those responsible for curriculum design.

Some of the primary pupils' negative comments on repetition, too much report writing (or simply copying of notes) suggested that the criticisms were not only confined to science; criticism was also made about the amount of writing involved in the humanities topics.

These findings suggest that most pupils would rather 'do' science than write about it and teachers may well be advised to consider whether some of the 'note-taking' aspects of science lessons are always necessary.

In this study it was noted that encouraging the pupils to ask questions in class was associated with a positive attitude towards the teacher(s) and the perceived quality of the pupil-teacher relationship was a significant predictor of the pupils' attitudes to science (particularly in Year 7). This may underline the need for teachers to place a greater priority than at present on listening to pupils' views and trying to resolve any conceptual difficulties as soon as possible.

The pupils' perceptions of the difficulty of science were associated with the pupils' perceptions of their own performance and, by the end of Year 8, the majority of the girls reported lower scores than the boys for their perceived performance. Although the perceived difficulty of the science curriculum did not seem to be a major influence on the pupils' attitudes in this longitudinal study, the greater tendency of the girls, compared with the boys, to record their views (particularly on the difficulty of the physical sciences) was clearly demonstrated. Whether the boys genuinely found science 'easy', or whether they exhibited a boyish 'bravado' in concealing their concerns (see Appendix 6.2), could only be established in a more detailed study concentrating on this particular aspect and examining perceived difficulty and actual performance. For some pupils, it was noted that the perceived difficulty and challenge in the work was an important factor in influencing positive attitudes to school science.

More detailed research on children's understanding of the concepts and vocabulary of science, and comparison with other subject areas, is necessary to identify the nature of the underlying problems and to attempt to derive some solutions. Pupils' confidence in their ability to learn, and to perform well, is an important factor in the development of positive attitudes and more teacher intervention in this respect may benefit girls' overall attitudes to science.

Stark and Gray (2001), following their recent survey of 6,000 pupils, have suggested that children had less confidence in their knowledge at age 13 to 14 than at age 8 to 9 and, although the authors suggest possible reasons for this apparent decline in confidence, the potential for a downward spiral, where lack of confidence leads to low achievement, lack of success and further lowering of confidence may be an issue which is very relevant in the context of teaching and learning at Key Stage 3.

It is possible that the assessment-orientated nature of the current science curriculum may be contributing to pupils' negative perceptions of their performance - this is an issue which should be addressed in any proposed curriculum changes. Less summative, and more formative, assessment could be beneficial with more encouragement of the pupils to 'think outside the box' and to develop their own special areas of interest.

Increasing pupils' involvement in lessons may be a crucial issue in improving pupils' attitudes to science and the shift from 'objectivist'[9] approaches to teaching to a 'constructivist' approach of shared learning may have many merits. This latter approach (see Chapter 1) can, however, be difficult to implement with less able or disaffected pupils who have not been encouraged from an early age to try to articulate their ideas. Improved strategies for the delivery of the science curriculum, by direct inter-active teaching through whole class teaching and small group work, may possibly be brought about through the implementation of the new Key Stage 3 Strategy for Science from September 2003 (Department for Education and Skills, 2002). Whether these strategies will have any measurable effect on pupils' attitudes to science in the next few years remains to be seen.

> "It is vital that pupils engage actively with their learning. This is the basis of scientific mastery, particularly when dealing with abstract phenomena. Without it, learning is superficial and soon lost"
>
> (Department for Education and Skills, 2002, p.41)

Other suggestions (Harlen, 2002 and Asoko, 2002) for improving pupils' engagement with the curriculum have been the inclusion within the science curriculum of 'consequence mapping', debate, role-play, and a greater focus on developing young children's ability to evaluate evidence. Matthews (2002)[10] has recently suggested that the development of pupils' 'emotional literacy' may also be a way of improving pupils' attitudes to science (and other subjects).

By the end of Year 8, most of the girls' were already losing interest in science and, in many cases, this loss of interest appeared to be related to the perceived repetition of content (see Chapter 6). It was possible that the degree of perceived repetition was influenced by the teachers' strategies for introducing a topic - some pupils might well have assumed (probably incorrectly) that, if an already familiar word was included in the teacher's introduction, then relatively little 'new' material would be on offer despite the teacher's intention of 'building on' existing knowledge through the 'spiral curriculum' (Bruner, 1960). To overcome this problem, teachers need to ensure that 're-visiting' the curriculum involves additional content, or a new approach to their teaching, it should not be synonymous with 'repeating' a topic.

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[9] Baird et al. (1990)

[10] based on the work of Greenhalgh (1994) who closely linked learning with emotional development - the pupils' capacity to learn depending on their ability to manage their 'inner' and 'outer' worlds.

Reference, both in this longitudinal study and elsewhere (see Chapter 3), to repetition of content particularly towards the end of KS2 and the apparent decline in interest in practical work/investigations at the end of KS3, may also suggest that these 'final' Key Stage years are where the attention to curriculum planning should be focussed. Sustaining, and preferably enhancing, an interest in school science remains a key issue and it is important to ensure that the stimulation of pupils' interests in the primary phase is enhanced (particularly for the girls), through the next three years of Key Stage 3.

Any further attempts at curriculum change will need seriously to address the perceived repetition of content in the curriculum. The findings of this longitudinal study, as well as comments from practising secondary teachers, suggest that much of the content of the early part of KS3 appears to have been covered by the end of KS2 and it is difficult to sustain positive attitudes in the secondary phase. Suggestions have been made about reducing the length of the current KS3 to two years instead of three but, because of the consequent effects on KS4, this would necessitate, at national level, yet another fundamental review of the entire examination system. If the content of the current KS3 were to remain relatively unchanged, the suggestion of shortening Key Stage 3 may be beneficial in some respects (e.g. in avoiding perceived repetition) but it may not actually improve the girls' attitudes - it would appear that, as reported in the pre-National Curriculum literature (Ormerod and Duckworth, 1975 and Haladyna et al., 1982), despite the temporary boost to attitudes in Year 7, they may have already 'switched off' from science before the end of KS2 and the problem of sustaining their interest may still remain.

It would appear that the National Curriculum has not, to date, sufficiently addressed the question of continuity and perceived repetition[11] of content during KS3 and KS4 and any further curriculum revision needs to take account of this. The new KS3 strategy (Department for Education and Skills, 2002), by encouraging the building of good transitional experiences, may be beneficial here.

Much has already been done (for example the increase in funding for primary science, via INSET etc., at the point of inception of the National Curriculum) to improve the quality of teaching and learning of science in the primary years but if the positive attitudes to science, recorded at the end of Year 5, are to be maintained, and preferably enhanced, in the secondary phase then good transfer experiences need to follow. The qualitative data

[11] The demotivation of some Year 8 pupils because of repetition of work was noted by Galton et al. (2002).

derived from this longitudinal study demonstrated that, although the pupils exhibited a range of minor concerns about the forthcoming transfer process, in retrospect it had been a good experience for the vast majority of pupils.

Pupils who have been involved in extension activities such as the British Association of Young Scientists (B.A.Y.S) Investigators Award (for pupils in the 8 to 13 age range) or the annual Science Year projects in their primary school need to be encouraged to continue with similar activities in the secondary phase (Hamill, 1997).

> "To undervalue or disregard the excellent work that goes on in primary schools is to sell our pupils short. Not to capitalise on what they have learnt and to take them forward from where they are is to risk them becoming bored and turned off science".
>
> (Hamill, 1997, p.21)

Current research suggests that good primary-secondary partnerships are essential if the pupils' interest and enthusiasm for science is to be extended.

Although comments on the relevance[12] of school science to 'real life' by the KS3 pupils participating in the longitudinal study were relatively few, the obvious preferences by the pupils for 'hands on' activities may suggest the case for a closer interaction between 'science' and 'technology'. Science and technology were both considered in parallel in the early days of the National Curriculum (Department of Education and Science/Welsh Office 1985b) but the 'academic' nature of science has set it apart from the 'design and make' requirements of technology (see Fowler, 1989, p.110). In view of the findings both in the longitudinal study and in other studies both pre- and post- National Curriculum (Ormerod and Duckworth, 1975; Harlen et al., 1981; Cullingford, 1987; Woolnough, 1997 and Osborne and Collins, 2000) that practical activities raised the vast majority of pupils' interest in science, it may be appropriate to re-think this route and to create more opportunities within the science syllabus for 'design and make' activities which have practical applications arising from the content of the science taught in school.

> "The priviledging of science over technology within the National Curriculum is akin to introducing the grammar of a language before practising its use. In both situations, the abstractness of the former over the relevance of the latter is simply incomprehensible to pupils"
>
> (Osborne and Collins, 2000, p.119).

[12] Osborne and Collins' (2000, p.119) commented that school science (at KS4) still seemed to be "unappealing to too many pupils".

The combination of 'scientific thinking' about function and purpose, together with the more practical aspects of design and technology, could possibly provide the basis for a more interesting curriculum for many pupils.

11.3.3 Gender issues: physics and biology

Whilst the influence of social, economic and cultural changes over the last decade need to be recognised, the numerous changes to the science curriculum at Key Stages 2 and 3 which were designed, *inter alia,* to improve attitudes to the physical sciences[13] (Department of Education and Science/Welsh Office, 1991; Department for Education and Employment, 1999 and Department for Education and Skills, 2002) seem to have had little effect on pupils', particularly the girls', attitudes. Despite all the encouragement to offer "girl-friendly" science (Smail, 1984a; Whyte et al., 1985; Kelly et al., 1984; Kelly, 1986, 1987 and Department of Education and Science, 1986), the girls appeared to have 'switched off' (possibly before the end of their primary education).

The introduction, in 2002, of the Ideas and Evidence component of the new KS3 Strategy for Science (Department for Education and Skills, 2002), with its emphasis on written evaluations and historical perspectives, may help to make the curriculum more interesting for the girls but, unless the issues are genuinely of interest to them, the hoped for effects may still not materialise.

An explanation for the boys' lack of enthusiasm for biology noted in this study may be that it is still perceived by boys as 'less scientific' and more 'artistic' in nature (see Chapter 10) – if this is so then teachers need to focus just as much attention on stimulating boys' enthusiasm for the biological (especially the plant) sciences as was devoted to girls' attitudes to the physical sciences (Smail, 1984a; Whyte et al., 1985; Kelly, 1986; Department of Education and Science, 1986; Keys, 1987 and Murphy and Beggs, 2003) in the last two decades. It has been suggested (Osborne and Collins, 2000, p.121) that the KS4 science curriculum might be made more attractive and relevant to pupils if *more* biology were incorporated (at the expense of physics and chemistry). Whilst this may have some attractions for the girls, and possibly increase the uptake of the biological sciences post-16, it may not be an appropriate route for increasing the boys' enthusiasm for biology if their negative attitudes towards the biological sciences (as observed in the longitudinal study) are already established before the end of Key Stage 3.

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[13] Attitudes to the physical sciences are generally regarded as a good indicator of pupils' attitudes to science as a whole (see Chapter 10.2.2)

From a teacher/researcher's perspective it now appears that, due primarily to concerns about Health and Safety, biology now offers less 'exciting' practical work (compared with physics and chemistry) than in the years prior to the National Curriculum. The substitution, by computer graphics, of 'hands on' experiences may have started to take its toll on KS3 pupils' (particularly the boys') enthusiasm but perhaps they tolerate it to the end of KS4 when the more able expect to indulge in 'real' biology at 'AS'/A' level en route to higher education courses in medicine or the veterinary sciences. More consideration needs to be given to the variety of tasks available in biology and the provision of more 'hands on' experiences wherever possible.

In recent years some of the issues arising from genetic modification and cloning (see McKie, 2000) may have adversely affected both boys' and girls' attitudes to biology. If this is true, earlier research may have under-estimated the effects of external influences such as media reports (British Broadcasting Corporation, 2002a, b and 2003a) on relatively young (10 to 13-year-old) pupils' attitudes and more research here may be appropriate.

11.3.4 Supplementary investigation: "out-of-school" factors and parental involvement

The vast majority of pupils experienced a wide range of "out-of-school" activities (sporting and otherwise). The parental data emphasised the positive association between early maternal involvement with the child's activities and the child's attitudes to science. However, fathers still appeared to be the prime 'tinkerers' and they were more likely to get involved with their sons, rather than their daughters, in 'tinkering' activities. By Year 6, the level of the fathers' involvement in mutual 'tinkering' activities[14] appeared to have a positive association with attitudes, particularly to the physical sciences.

11.3.5 Comment

Whilst this parental involvement in the pupils' activities during the primary phase has been shown to have a positive association with the pupils' attitudes to science, the main predictor of pupils' attitudes in the early stages of their secondary education was the pupils' own perceptions of their performance in science. The quality of the pupil-teacher relationship in the first year of secondary school was also demonstrated as a contributing

[14] Other associations such as the level of the fathers' science education, and the fathers' attitudes to their own secondary science education, with the pupils' attitudes in Year 7 were also noted (see Chapter 9).

factor. More 'dialogue' between pupil and teacher, allowing more discussion and engagement by pupils and an appreciation of alternative explanations of some scientific phenomena (see Chapter 1), may be beneficial here. Teachers play a significant role in raising pupils' confidence in their ability in the classroom and further curriculum changes will need to embrace some of the issues discussed in this research which currently make science less attractive as a subject for further study.

Maintaining, and preferably enhancing, during the secondary years the enthusiasm for science exhibited by the end of Year 5 of the primary school remains a key issue in science education. Despite the numerous curriculum changes (see Chapter 2) which have taken place over the last decade, the perceived repetition of content and lack of progression through the key stages needs resolution. Science is still not a popular subject within schools and the apparent irrelevance of school science to the knowledge and skills needed for their future lives may still be a negative influence for many pupils, particularly girls, on their attitudes.

Gender differences in attitudes to the physical sciences, noted before the inception of the National Curriculum for Science (Smail, 1984a, b; Smail and Kelly, 1984b; Kelly, 1986; Department of Education and Science, 1986 and Keys, 1987), were key issues of this research. Although the boys who participated in this study demonstrated, against the national trend, positive attitudes to the physical sciences by the end of Year 8, the girls' negative attitudes to the physical sciences were still apparent. More than a decade after the introduction of the National Curriculum, explanations (Ormerod and Duckworth, 1975; Ormerod, 1975b; Clarricoates, 1978; Whyte et al., 1985; Kelly, 1986 and Skelton, 1989) are available for the girls' dislike of the 'male' physical sciences and, conversely, for the boys' lack of interest in 'female' biology, but strategies employed to reduce the gender gap, particularly for the girls' negative attitudes to the physical sciences, have not so far been successful.

> "We have not managed to change the sex differences in attitudes to science. ....Sex stereotypes by subject choice still prevails and seem to run deep within the culture. This cannot be a satisfactory result of science teaching it must be addressed as a continuing major issue; awareness is not enough".
>
> (Bricheno et al., 2000, p.152)

Bibliography

Abdou, F.M. (1984). *Development of selected affected outcomes of the learning-teaching process in science: attitude to science, scientific interests and science attitudes for early and middle adolescent stage students in secondary schools in South Wales.* Unpublished Ph.D. Thesis. University of Cardiff.

Aikenhead, G.S. and Jegede, O.J. (1999). Cross-cultural science education: a cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching* 36 (3), pp. 269-287.

Ajzen, I. and Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour.* Englewood Cliffs, New Jersey: Prentice Hall.

Allport, G.W. (1954). Attitudes in the history of social psychology. In: Warren, N. and Jahoda, M., eds. (1973). *Attitudes - selected readings. 2nd Edn.* Harmondsworth, Middx: Penguin Books Ltd. pp. 19-25.

Aron, A. and Aron, E.N. (1999). *Statistics for Psychology. 2nd Edn.* Upper Saddle River, New Jersey: Prentice Hall.

Anslow, J. (1999). Stability and science education. *School Science Review* 80 (292), p.19.

Asoko, H. (2002). Primary Science Review 2001-2002: some themes of interest to secondary teachers. *School Science Review* (2002), 84 (306), pp. 111-117.

Ausubel, D.P., Novak, J.D. and Hanesian, H. (1978). *Educational Psychology: a cognitive view. 2nd. Edn.* London: Holt, Rinehart and Winston.

Ballham, A. (1964). *Relationship between personality and academic attainment as measured by the G.C.E. 'O' level.* Unpublished M.Ed. Thesis. University of Manchester.

Barnes, D. (1986). Language in the secondary classroom. In: Barnes, D., Britton, J. and Torbe, M. (1986). *Language, the learner and the school.* Harmondsworth, Middx: Penguin Books Ltd.

Blair, G. (2003). Extract provided from 'Statistics on AS/AS level entries for the sciences' 1991/2 and 1999/2000. (http://www.dfes.gov.uk/statistics).

Bodmer Report (1985). *The public understanding of science: report of a Royal Society ad hoc group endorsed by the Council of the Royal Society.* London: Royal Society.

Bradley, J. and Hutchings, D. (1973). Concepts of science and scientists as factors affecting subject choice in secondary schools. *School Science Review* 55 (190), pp. 8-15.

Breakwell, G.M. and Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science* 1, pp. 183-197.

Bricheno, P. (2001). *Pupil attitudes: a longitudinal study of children's attitudes at transfer from primary to secondary school.* Unpublished Ph.D. Thesis. University of Greenwich.

Bricheno, P., Johnston, J. and Sears, J. (2000). Children's attitudes to science. Beyond the men in white coats. In: Sears, J. and Sorenson, P., eds. *Issues in Science and Technology.* London: Routledge Falmer.

British Broadcasting Corporation (2002a). *Human cloning 'flawed'.* BBC News, 10th April. (http://news.bbc.co.uk/1//hi/sci/tech/2936401.stm).

British Broadcasting Corporation (2002b). *'Incurable diseases' claim over GM trials.* BBC News, 13th November. (http://news.bbc.co.uk/1/hi/scotland//2459007.stm).

British Broadcasting Corporation (2002c). *Obesity threatens children's lifespans.* BBC News, 26th December. (http://news.bbc.co.uk/1/hi/health/2606323.stm).

British Broadcasting Corporation (2003a). *Dolly the sheep clone dies young.* BBC News, 14th February. (http://news.bbc.co.uk/1//hi/sci/tech/2764039.stm).

British Broadcasting Corporation (2003b). *'Hidden' obesity in UK's young.* BBC News, 21st March. (http://news.bbc.co.uk/1//hi/health/2869335.stm).

Bronowski, J. (1973). *The Ascent of Man.* London: British Broadcasting Corporation.

Brown, S.A. (1972). *The pupils' view of science in the middle years.* Paper read to the D.E.S./A.T.C.D.E. Joint Conference for Science Tutors, City of Leeds and Carnegie College, March, 1972.

Bruner, J.S. (1960) The Process of Education. Cambridge, MA: Harvard University Press.

Butler, J.R. (1966). *The formation of occupational choice among grammar school pupils.* Unpublished M.A. Thesis. University of Nottingham.

Cabinet Office (1972). *A Framework for Government Research and Development.* Command 5046. London: H. M. Stationery Office.

Cabinet Office (1993). *Realising our Potential: A Strategy for Science, Engineering and Technology. White Paper No. 2250.* London: Office of Public Services and Science.

Chown, S.M. (1958). The formation of occupational choice amongst grammar school pupils. *Occupational Psychology* 32 3, pp. 171-182.

Clarricoates, K. (1978). Dinosaurs in the classroom: a re-examination of some aspects of the 'hidden curriculum' in primary schools. *Women's Studies International Quarterly* 1 (4), pp. 353-364.

Cohen, L. and Mannion, L. (1994). *Research Methods in Education. 4th Edn.* London: Routledge.

Colley, A., Comber, C. and Hargreaves, D.J. (1994). School subject preferences of pupils in single sex and co-educational secondary schools. *Educational Studies* 20 (2), pp. 379-385.

Comber, L.C. and Keeves, J.P. (1973). *Science education in nineteen countries.* Stockholm: Almqvist and Wiksell.

Costa, V.B. (1995). When science is "another world": Relationships between worlds of family, friends, school and science. *Science Education* 79, pp. 313-333.

Council for Scientific Policy (1968). *Inquiry into the flow of candidates in science and technology into higher education (The Dainton Report).* London: H.M. Stationery Office.

Council for Science and Technology (1999). *School Science: fit for the future?* Retrieved from the World Wide Web: July 2003 (http://www.cst.gov.uk/cst/sged29812.htm).

Cronbach, L. J. (1970). Test validation. In: Thorndike, R.L., ed. *Educational Measurement.* Washington D.C: American Council on Education.

Cullingford, C. (1987). Children's attitudes to teaching styles. *Oxford Review of Education* 13 (3), pp. 331-339.

Dearing, R. (1993). *The National Curriculum and its assessment: Final report. December 1993.* London: School Curriculum and Assessment Authority.

Dearing, R. (1996). *Review of qualifications for 16-19 year olds: mathematics and the sciences.* Hayes: School Curriculum and Assessment Authority.

Department of Education and Science (1938). *Consultative committee on secondary education (The Spens Report).* London: H.M.Stationery Office.

Department of Education and Science (1965). *The reorganisation of secondary education, Circular 10/65.* London: H.M. Stationery Office.

Department of Education and Science (1972). *Education: A framework for expansion. White Paper. Command 5174.* London: H.M. Stationery Office.

Department of Education and Science/Welsh Office (1977a). *Education in schools: a consultative document. Command 6869. Green Paper.* London: H.M. Stationery Office.

Department of Education and Science (1977b). *Ten good schools: a secondary school enquiry. Inspectorate of Schools. HMI Series for Discussion 1.* London: H.M. Stationery Office.

Department of Education and Science/Welsh Office (1977c). *Curriculum 11-16. H.M. Inspectorate.* London: H.M. Stationery Office.

Department of Education and Science (1978). *Primary education in England. H.M. Inspectorate.* London: H.M. Stationery Office.

Department of Education and Science (1980a). *A framework for the school curriculum proposals for consultation by the Secretaries of State for Education and Science and for Wales.* London: H.M. Stationery Office.

Department of Education and Science (1980b). *A view of the curriculum. HMI Series: Matters for Discussion 11.* London: H.M. Stationery Office.

Department of Education and Science (1981a). *Curriculum 11-16: a review of progress.* London: H.M. Stationery Office.

Department of Education and Science/Welsh Office (1981b). *The school curriculum.* London: H.M. Stationery Office.

Department of Education and Science/Welsh Office (1984). *The organisation and content of the 5-16 Curriculum.* London: H.M. Stationery Office.

Department of Education and Science/Welsh Office (1985a). *Better Schools. Command 9469.* London: H.M. Stationery Office.

Department of Education and Science (1985b). *The curriculum from 5 to 16. HMI Series: Curriculum Matters 2.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1985c). *Science 5-16: a statement of policy.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1985d). *Science in schools: age 11.* Report No. 4. London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1985e). *The education system of England and Wales.* London: H. M. Stationery Office.

Department of Education and Science (1986). *Girls and Physics. APU Occasional Paper 4. Reflections on APU Survey Findings.* S. Johnson and P. Murphy eds. APU Science Team, The University of Leeds and London: Kings College.

Department of Education and Science/Welsh Office (1987). *The National Curriculum 5-16. A consultation document.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1988). *The curriculum from 5 to 16. The responses to Curriculum Matters 2.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1988). *Science for ages 5-16. Proposals of the Secretary of State for Education and Science and the Secretary of State for Wales.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1989). *Science in the National Curriculum.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1991). *Science in the National Curriculum. Proposals of the Secretary of State for Education and Science and the Secretary of State for Wales.* London: H. M. Stationery Office.

Department of Education and Science/Welsh Office (1995). *Science in the National Curriculum.* London: H. M. Stationery Office.

Department for Education and Employment (1999). *The National Curriculum for England. Science: Key Stages 1 to 4. London:* Department for Education and Employment /Qualifications and Curriculum Authority.

Department for Education and Skills (2002). *Key Stage 3 National Strategy. Framework for teaching science: Years 7, 8 and 9.* London: H. M. Stationery Office.

Dey, I. (1993). *Qualitative Data Analysis: a user-friendly guide for social scientists.* London and New York: Routledge.

Doherty, J. and Dawe, J. (1985). The relationship between developmental maturity and attitude to school science: an exploratory study. *Educational Studies* 11 (2), pp. 93-107.

Donaldson, M. (1978). *Children's minds.* London: Fontana.

Donnelly, J. F. (2000). Secondary science teaching under the National Curriculum. *School Science Review* 81 (296), pp.27- 35.

Drever, E. (1995). Using semi-structured interviews in small scale research: a teacher's guide. SCRE Publication 129. Edinburgh: The Scottish Council for Research in Education.

Driver, R., Asoko, H., Leach, J., Mortimer, E. and Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher* 23, pp. 5-12.

Driver, R., Leach, J., Millar, R. and Scott, P. (1996). *Young peoples' image of science.* Buckingham: Open University Press.

Driver, R., Child, D., Gott, R., Head, J., Johnson, S., Worsley, C. and Wylie, F. (1984). Science in Schools: Age 15. Research Report No.2. London: H. M. Stationery Office.

Driver, R. and Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education* 13, pp. 105-122.

Duckworth, D. and Entwistle, N. J. (1974). The swing from science: a perspective from hindsight. *Education Research* 17 (1), pp. 48-53.

Eagly, A.H. and Chaiken, S. (1993). *The Psychology of Attitudes.* Orlando, USA: Harcourt Brace Jovanovich College Publishers.

Education Reform Act (1988). Elizabeth II. Chapter 40. London: H.M. Stationery Office.

Fowler, W.S. (1988). *Towards the National Curriculum. Discussion and Control in the English Educational System 1965-1988.* London: Kogan Page Ltd.

Fraser, B.J. (1978). Development of a test of science related activities. *Science Education* 62 (4), pp. 509 –515.

Frost, J. (1995) ed. *Teaching Science.* London: Woburn Press.

Galton, M., Gray, J. and Ruddock J. (2002). *Transfers, transitions and pupil progress. A research and development project.* Cambridge: Homerton College.

Galton, M. and Simon, B. eds. (1980). *Progress and performance in the primary classroom.* London: Routledge and Kegan Paul.

Gardner, P.L. (1975). Attitudes to science: a review. *Studies in Science Education* 2, pp. 1-41.

Geake, J. (1993). Parents as a resource for science and technology education. *Australian Science Teachers Journal* 39 (2), p. 52.

Gill, A.A. (1996). Another nail in the boffin. *The Sunday Times. The Culture,* 8th September, pp. 2-3.

Glenn, N. (1977). *Cohort Analysis.* Beverley Hills, CA: Sage Publications.

Glenny, G. (1995). Establishing children's views. In: Salmon, P. *Psychology in the classroom. Reconstructing teachers and learners.* London: Cassell, pp. 6-12.

Gornall, L. and Thomas, B. (1998). The development of the communication of science. *Education in Science* 178, pp. 18-19.

Greenhalgh, P. (1994). *Emotional growth and learning.* London: Routledge.

Greig, A. and Taylor, J. (1999). *Doing Research with Children.* London: Sage.

Gross, R.D. (1992). *Psychology: the science of mind and behaviour. 2nd Edn.* London: Hodder and Stoughton Educational.

Haladyna, T., Olsen, R. and Shaughnessy, J. (1982). Relations of student, teacher and learning environment variables to attitudes to science. *Science Education* 66 (5), pp. 671-687.

Hamill, A. (1997). Science education for the new millennium. *School Science Review* 79 (286), pp. 21-26.

Harlen, W. (1997). Primary teachers' understanding in science and its impact in the classroom. *Research in Science Education* 27 (3), pp. 323-337.

Harlen, W. (2002). Links to everyday life: the roots of scientific literacy. *Primary Science Review* 71, pp. 8-10.

Harlen, W., Black, P. and Johnson, S. (1981). *Science in schools: age 11. Report No. 1.* London: H. M. Stationery Office.

Harlen, W., Black, P., Johnson, S. and Palacio, D. (1983). *Science in schools: age 11. Report No. 2.* London: H. M. Stationery Office.

Harlen, W., Black, P., Johnson, S. and Palacio, D. (1983). *Science in schools: age 11. Report No. 2.* London: H. M. Stationery Office.

Harlen, W., Black, P., Johnson, S., Palacio, D. and Russell, T. (1984). *Science in schools: age 11. Report No. 3.* London: H M.Stationery Office.

Harlen, W., Holroyd, C. and Byrne, M (1995). *Confidence and understanding in teaching science and technology in primary schools.* Edinburgh: Scottish Council for Research in Education.

Harris, S., Keys, W. and Fernandes, C. (1997). *Third International Mathematics and Science Study. Second national report Part 1. Achievement in mathematics and science at age 9 in England.* Slough, Berks: N.F.E.R.

Harvey, T. J. and Edwards, B. (1980). Children's expectations and realisations of science. *British Journal of Educational Psychology* 50, pp.74-76.

Havard, N. (1996). Student attitudes to studying A-level sciences. *Public Understanding of Science* 5 (4), pp. 321-330.

Hendley, D., Parkinson, J., Stables, A. and Tanner, H. (1995). Gender differences in pupil attitudes to the national curriculum foundation subjects of English, mathematics, science and technology in Key Stage 3 in South Wales. *Educational Studies* 21 (1), pp. 85-97.

Hendley, D., Stables, S. and Stables, A. (1996). Pupils' subject preferences at key stage 3 in South Wales. *Educational Studies* 22 (2), pp. 177-187.

Henerson, M.E., Morris, L. L. and Fitz-Gibbon C.T. (1987). *How to measure attitudes.* London: Sage Publications.

Hewison, J. (1982). *Attitudes to science of pupils aged 10-13 in middle and high schools.* Unpublished M.Ed. Thesis. University of Newcastle.

Hill, G.B. (1965). Choice of career by grammar schoolboys. *Occupational Psychology* 39, pp.279-287.

Himmelfarb, S. (1993). Chapter 2. Measurement of Attitudes. In: Eagly, A.H. and Chaiken, S. (1993). *The Psychology of Attitudes.* Orlando, USA: Harcourt Brace Jovanovich College Publishers.

Hislop, N.L. and Weeks, E.J. (1948a). The interests of schoolchildren. I. *School Science Review* 29 (109), pp. 281-294.

Hislop, N.L. and Weeks, E.J. (1948b). The interests of schoolchildren. II. *School Science Review* 30 (110), pp. 7-14.

H. M. Inspectors of Schools (1991). *Technical and Vocational Education Initiative (TVEI): England and Wales 1983-90.* London: H. M. Stationery Office.

H. M. Inspectors of Schools (1994). *Effective teaching and learning in Scottish secondary schools. The Sciences.* Edinburgh: The Scottish Office Education Department.

H. M. Treasury (2002). *SET for success. The supply of people with science, technology, engineering and mathematical skills.* The Report of Sir Gareth Roberts' Review. Retrieved from the World Wide Web. July 2002. *(http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/ research_and_enterprise/ent_res_roberts.cfm*

Hodson, D. and Freeman, P. (1983). The effect of primary science on interest in science: some research problems. *Research in Science and Technological Education* 1 (1), pp.109-118.

Hodson, D. and Hodson, J. (1998a). From constructivism to social constructivism: a Vygotskian perspective on teaching and learning science. *School Science Review* 79 (289), pp. 33-41.

Howell, D.C. (1997). *Statistical Methods for Psychology. 4th Edn.* Belmont, CA: Duxbury.

Hudson, L. (1963). The relation of psychological test scores to academic bias. *British Journal of Educational Psychology* 33, pp. 120-131.

Hutchings, D. (1975). *Factors affecting pupils' choice of courses which reflect a scientific or technological bias.* Oxford: Department of Educational Studies, University of Oxford.

James, A. (1993). *Childhood identities. Self and social relationships in the experience of the child.* Edinburgh: Edinburgh University Press.

Jenkin, P. (2002). The role of science teachers in the drive for scientific literacy. Presidential address delivered at the Annual Meeting of the Association for Science Education, University of Liverpool, January 2002. *School Science Review* 83 (204), pp. 21-25.

Jennings, K. and Hargreaves, D. (1981). Children's attitudes to secondary school transfer. *Education Studies* 7 (1), pp. 35-39.

Johnson, S. (1987). Gender differences in science: parallels in interest, experience and performance. *International Journal of Science Education* 9 (4), pp. 467-481.

Johnson, S. (1989). *National assessment: the APU approach.* London: H.M. Stationery Office.

Johnson, S. and Murphy, P. (1984). The underachievement of girls in physics: towards explanations. *European Journal of Science Education* 6, pp. 401-411.

Kahle, J.B. and Lakes, M.K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching* 20, pp. 131-140.

Keeves, J.P. (1973). *Educational environment and student achievement.* Stockholm: Almqvist and Wiksell.

Keeves, J.P. (1975). The home, the school and achievement in mathematics and science. *Science Education* 59 (4), pp. 439-459.

Kelly, A. (1978). *Girls and science. An international study of sex differences in school science achievement.* Stockholm: Almqvist and Wiksell.

Kelly, A. (1986). The development of girls' and boys' attitudes to science: a longitudinal study. *European Journal of Science Education* 8 (4), pp. 399-412.

Kelly, A. (1987). Why girls don't do science. In: Kelly, A. ed. *Science for girls?* Milton Keynes: Open University Press, pp.12-17.

Kelly, A. and Smail, B. (1986). *Sex stereotypes and attitudes to science among eleven year old children.* British Journal of Educational Psychology 56, pp.156-158.

Kelly, A., Smail, B. and Whyte, J. (1981). *Initial GIST survey: results and implications.* Manchester: G.I.S.T., Manchester Polytechnic.

Kelly, A., Whyte, J. and Smail, B. (1984). *Final report on the Girls Into Science and Technology project.* Manchester: Department of Sociology, Manchester University.

Kelly, G. A. (1955). *The Psychology of Personal Constructs.* New York: Norton.

Kelly, P.J. (1961). An investigation of the factors which influence grammar school pupils to prefer scientific subjects. *British Journal of Education Psychology* 31, pp. 43-44.

Keys, W. (1978a). *Some cognitive affective and personality correlates of subject bias amongst able English boys and girls in the middle years of secondary education.* Unpublished Ph.D. Thesis. Brunel University.

Keys, W. (1987). *Aspects of science education in English schools.* Windsor, Berks: N.F.E.R-Nelson Publishing Company.

Keys, W., Harris, S. and Fernandes, C. (1996a). *Third International Mathematics and Science Study: First National Report, Part 1.* Slough, Berks: N.F.E.R.

Keys, W., Harris, S. and Fernandes, C. (1996b). *Third International Mathematics and Science Study, National Reports. Appendices: Additional information relating to the study in England.* Slough, Berks: N.F.E.R.

Keys, W., Harris, S. and Fernandes, C. (1997). *Third International Mathematics and Science Study. Second national report Part 2. Patterns of mathematics and science teaching in upper primary schools in England and eight other countries.* Slough, Berks: N. F. E.R.

Khaligh, N., Johnson, S., Murphy, P., Orgee, T. and Schofield, B. (1986). *Science in schools: Age 13.* Research Report No. 4. London: H.M. Stationery Office.

Kinnear, P.R. and Gray, C.D. (2001). *SPSS for Windows Made Simple. Release 10.* Hove, Sussex: Psychology Press Ltd.

Koelsche, C.L. and Newberry, S.L. (1971). A study of the relationship between certain variables and the science interests of children. *Journal of Research in Science Teaching* 8 (3), pp. 237-241.

Larson, J.O. (1995). *Fatima's rules and other elements of an unintended chemistry curriculum.* Paper presented at the American Educational Research Association Annual Meeting, San Francisco, California, April, 1995.

Leach, J. and Scott, P. (2000). Children's thinking, learning, teaching and constructivism. In: *Good practice in science teaching: what research has to say.* eds. Monk, M. and Osborne, J., eds. Buckingham: Open University Press. pp. 41-56.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology* 22, 140.

Lord, P. and Harland, J. (2000). Pupils' experiences and perspectives of the National Curriculum. Research review. Retrieved from the World Wide Web. March 2002. (http://www.qca.org.uk/rs/rer/pupils_perspectives.asp).

Lord, P. (2001). Pupils' experiences and perspectives of the National Curriculum. Updating the research review conducted for the QCA, March 2001. Retrieved from the World Wide Web. March 2002. (http://www.qca.org.uk/rs/rer/pupils_perspectives.asp).

Lugones, M. (1987). Playfulness, "world"- travelling, and loving perception. *Hypatia* 2 (2), pp. 3-19.

Maccoby, E.E. and Jacklin, C.N. (1974). *The psychology of sex differences.* Stanford: Stanford University Press.

Marshall, P. (1988). *Transition and continuity in the educational process.* London: Kogan Page Ltd.

Matthews, M.R. (1993). Constructivism and science education: some epistemological issues. *Journal of Science Education and Technology* 2, pp. 359-370.

Matthews, M.R. (1995). *Challenging New Zealand science education.* Palmerston North, New Zealand: Dunmore Press.

Matthews, B. (2002). Why is emotional literacy important to science teachers? *School Science Review* 84 (306), pp. 97.

May, T. (1993). *Social research: issues, methods and process.* Buckingham: Open University Press.

Mayall, B. (1994) ed. *Children's childhoods: observed and experienced.* London: Falmer Press.

McCune, R. (1998). Science education for the year 2000 and beyond (An introduction). *Education in Science* Feb. (176), pp. 17-20.

McKenzie, A.E.E. (1941). Teaching principles. *School Science Review* 22 (87), pp. 244-251.

McKie, R. (2000). *Scientists abandon 'inefficient' cloning.* The Observer, 18th June, p.6.

Measor, L. and Sikes, P.J. (1992). *Gender and schools.* London: Cassell.

Measor, L. and Woods, P. (1984). *Changing schools: pupils' perspectives on transfer to a comprehensive.* Milton Keynes: Open University Press.

Meyer, G.R. (1961). Factors affecting the scientific interest of a selected group of English secondary pupils. *Australian Journal of Education* 5, pp. 27-40 and pp.105-115.

Meyer, G.R. (1963). Factors related to scientific attitudes in the secondary schools of an Australian city. *Australian Journal of Education* 7, pp.21-40.

Meyer, G.R. and Penfold, D.M.E. (1961). Factors associated with interest in science. *British Journal of Educational Psychology* 31 (1), pp.33-37.

Menard, S. (1991). *Longitudinal research. Quantitative applications in the social sciences.* Sage University Papers Series, Number 07-076. California: Sage Publications.

Millar, R. (1989). Constructive criticisms. *International Journal of Science Education* 11, 587-596.

Millar, R. (1996). Towards a science curriculum for public understanding. *School Science Review* 77 (280), pp.7-18.

Millar, R. and Osborne, J. (1998). *Beyond 2000 - science education for the future.* King's College London, School of Education, Cornwall House, London SE1 8WA.

Millar, R., Osborne, J. and Nott, M. (1998). Science education for the future. *School Science Review* 80 (291), pp. 19-28.

Miller, D., Parkhouse, P., Eagle, R. and Evans, T. (1999). *Pupils and core subjects: a study of the attitudes of some pupils aged 11-16.* Paper presented at the British Educational Research Association Annual Conference, University of Sussex at Brighton, September 2nd –5th. Retrieved from the World Wide Web. November 1999. *(http://www.leeds.ac.uk/educol/documents/00001427.htn).*

Moon, B. (1991). *A Guide to the National Curriculum.* Oxford: Oxford University Press.

Moon, B. and Mortimore, P. (1989). *The National Curriculum: straightjacket (sic) or safetynet?* London: Education Reform Group.

↑ Monk, M. and Osborne, J., eds. (2000). *Good practice in science teaching: what research has to say?* Buckingham: Open University Press.

Morrow, V. and Richards, M. (1996). The ethics of social research with children: an overview. *Children and Society* 10, pp.90-105.

Mortimore, P., Sammonds, P., Stoll, L., Lewis, D. and Ecob, R. (1988). *School matters: the junior years.* Wells, Somerset: Open Books.

Murphy, C. and Beggs, J. (2003). Children's perceptions of school science. *School Science Review* 84 (308), pp.109-116.

Myers, R.E. and Fouts, J.T. (1992). A cluster analysis of high school science classroom environments and attitude towards science. *Journal of Research in Science Teaching* 29 (9), pp. 929-937.

National Curriculum Council (1989). *An introduction to the National Curriculum. Primary Science 1 and 2: Science in the Primary Curriculum.* York: National Curriculum Council.

National Curriculum Council (1991). *Science in the National Curriculum. A report to the Secretary of State for Education and Science on the statutory consultation for attainment targets and programmes of study in science.* York: National Curriculum Council.

Naughton, J. (1997). "Science in court: Bunsen burners or Beckett - why can't we have both?" *Observer Review,* 14th September.

OFSTED (1995). *Science: a review of inspection findings 1993/4.* London: H M Stationery Office.

Oppenheim, A.N. (1966). *Questionnaire design and attitude measurement.* London: Heinemann.

Ormerod, M.B. (1975a). *Single sex and co-education: an analysis of pupils' science preferences and choices and their attitudes to other aspects of science under these two systems.* Paper presented at the conference on Girls and Science Education sponsored by the Nuffield Foundation at Chelsea Centre for Science Education, March 1987.

Ormerod, M.B. (1975b). Subject preference and choice in co-educational and single sex secondary schools. *British Journal of Educational Psychology* 45 (3), pp. 35-56.

Ormerod, M.B. (1976). *The characteristics and correlates of pupils' attitudes to science in the middle years of secondary education.* Unpublished Ph.D. thesis. Brunel University.

Ormerod, M.B. and Duckworth (1975). *Pupils' attitudes to science. A review of research.* Slough, Berks: N.F.E.R.

Osborne, J.F. and Collins, S. (2000). *Pupils and parents' views of the school science curriculum.* London: King's College.

Osgood, C.E., Suci, G.J. and Tannenbaum, P.H. (1957). *The measurement of measuring.* Urbana: University of Illinois Press.

Parkinson, J., Hendley, D., Tanner, H. and Stables, A. (1998). Pupils' attitudes to science in Key Stage 3 of the National Curriculum: a study of pupils in South Wales. *Research in Science and Technological Education* 16 (2), pp. 165-176.

Pell, T. and Jarvis, T. (2001). Developing attitude to science scales for use with children of ages from five to eleven years. *International Journal of Science Education* 23 (8), pp. 847-862.

Peaker, G.F. (1971). *The Plowden Children Four Years Later.* Windsor, Berks: N.F.E.R.

Petty, R.E. (1995). Attitude change. In: Tesser, A., ed. *Advanced Social Psychology.* New York: McGraw Hill Inc.

Pheasant, J.H. (1961). The influence of school on the choice of science careers. *British Journal of Educational Psychology* 31 (1), pp. 38-42.

Piburn, M.D. and Baker, D.R. (1993). If I were the teacher.........qualitative study of attitude towards science. *Science Education* 77, pp. 393-406.

Pollard, A., Broadfoot, P., Croll, P., Osborn, M. and Abbott, D. (1994). *Changing English primary schools: the impact of the Education Reform Act at Key Stage One.* London: Cassell.

Ponchaud, B. (2001). *Primary science: where next?* Presentation at the Association for Science Education Annual Meeting, Guildford, 2001.

Posner, G.J., Strike, K.A., Hewson, P.W. and Gertzog, W.A. (1982). Accommodation of a scientific concept: toward a theory of conceptual change. *Science Education* 66, pp. 211-227.

Potter, J. and Wetherall, M. (1987). *Discourse and social psychology: beyond attitudes and behaviour.* London: Sage Publications.

Pounds, K. (1998). *The future of science hinges on PUS in the schools.* Retrieved from the World Wide Web. February 1999. (http://www.dur.ac.uk/~dss0www1).

Powney, J. and Watts, M. (1987). *Interviewing in educational research.* London: Routledge and Kegan Paul.

Qualifications and Curriculum Authority (1999). *The review of the National Curriculum in England – the Secretary of State's proposals.* London: Qualifications and Curriculum Authority.

Ramsden, J. M. (1998). Mission impossible? Can anything be done about attitudes to science? *International Journal of Science Education* 20 (2), pp.125-137.

Reich, B. and Adcock, C. (1976). *Values, Attitudes and Behaviour Change.* Herriot, P., ed. London: Methuen.

Reiss, M. J. (2002). Reforming school science education in the light of pupils' views and the boundaries of science. *School Science Review* 84 (307), pp. 71-77.

Reisz, E. D., McNabb, T.F., Stephen, S.L. and Ziomek, R.L. (1994). Gender differences in high school students' attitudes toward science: research and intervention. *Journal of Women and Minorities in Science and Engineering* 1 (4), pp. 273-289.

Revill, J. (2002). *Misery of fat children obsessed by junk food.* The Observer, 15th September, p.10.

Robinson, J.T. (1969). Philosophical and historical bases of science teaching. *Review of Education Research* 39, pp. 459-471.

Robson, C. (1993). *Real world research.* London: Blackwell.

'Rothschild report' (1971). *A framework for Government research and development presented to Parliament by the Lord Privy Seal.* Command 4814. London: H. M. Stationery Office.

Russell, A. (1999). Curriculum 2000 and beyond - a response. *School Science Review* 81 (295), pp. 12-14.

Rutter, M., Maughan, B., Mortimore, P., Ouston, J. and Smith, A. (1979). *Fifteen thousand hours: secondary schools and their effects on children.* London: Open Books.

Salmon, P. (1995). *Psychology in the classroom: reconstructing teachers and learners.* London: Cassell.

Schools Council (1965). *Change and response. The first year's work: October 1964-September 1965.* London: H.M. Stationery Office.

School Curriculum and Assessment Authority (1994). Science in the National Curriculum. Draft Proposals. London: S.C.A.A.

Schutz, A. and Luckman, T. (1973). *Structures of the Life World.* London: Heineman.

Secondary Science Curriculum Review (1983). *Science education 11-16: proposals for action and consultation.* London: S.S.C.R.

Selmes, C. (1969). The attitudes of 12/13 year old pupils to science and scientists. *School Science Review* 51 (174), pp.7-14.

Shayler, M. (1974). Conceptual demands in the Nuffield 'O' level physics course. *School Science Review* 54 (186), pp.26-34.

Sherwood Taylor, F. (1936). *The World of Science.* London: Heinemann.

Short, G. (1992). Secondary transfer: the multi-racial dimension. *Research in Education* 48, pp. 111-113.

Short, G. and Carrington, B. (1989). Discourse on gender: the perceptions of children aged between six and eleven. In: Skelton, C. (1989) *Whatever happens to little women? Gender and primary schooling.* Milton Keynes: Open University Press.

Simon, S. (2000). Students' attitudes towards science. In: Monk, M. and Osborne, J. eds. *Good practice in science teaching: what research has to say?* Buckingham: Open University Press, pp. 104-119.

Simpson, R.D. and Oliver, J.S. (1990). A summary of the major influences on attitude toward and achievement in science among adolescent students. *Science Education* 74 (1), pp. 1-18.

Skelton, C. (1989). *Whatever happens to little women? Gender and primary schooling.* Milton Keynes: Open University Press.

Smail, B. (1984a). *Factors affecting girls' interest in science on entry to secondary education.* Unpublished M.Ed. Thesis. University of Manchester.

Smail, B. (1984b). *Girl friendly science: avoiding sex-bias in the curriculum.* London: Longman.

Smail, B. and Kelly, A. (1984a). Sex differences in science and technology among eleven year old schoolchildren. I: Cognitive. *Research in Science and Technology Education* 2, pp. 61-76.

Smail, B. and Kelly, A. (1984b). Sex differences in science and technology among eleven year old schoolchildren. II: Attitudes. *Research in Science and Technology Education* 2, pp. 87-106.

Solomon, J. (1983). Learning about energy: How pupils think in two domains. *European Journal of Science Education* 5, pp. 49-59.

Solomon, J. (1994). The rise and fall of constructivism. *Studies in Science Education* (1994) 23, pp. 1-19.

Solomon, J., Scott, L. and Duveen, J. (1996). Large scale exploration of pupils' understandings of the nature of science. *Science Education* 80, pp. 493-508.

Staats, A.W. and Staats, C.K. (1958). Attitudes established by classical conditioning. *Journal of Abnormal and Social Psychology* 57, pp. 37- 40.

Stanworth, M. (1981). *Gender and schooling: a study of social divisions in the classroom.* The Women's Research and Resources Centre Publications Collective. London: Hutchinson & Co. (Publishers) Ltd.

Stanley, L. and Temple, B. (1993). *Using computers for analysing qualitative datasets.* Manchester: Sociology Department, University of Manchester, Manchester M13 9PL.

Stark, R. and Gray, D. (2001). What science do they think they know? *Primary Science Review* 68, pp. 8-11.

Statutory Instrument (1991), No. 2897. *The Education (National Curriculum) (Attainment Targets and Programmes of Study in Science) Order 1991.* London: H.M. Stationery Office.

Statutory Instrument (1994), No. 53. *The Education (National Curriculum) (Attainment Targets and Programmes of Study in Science) Order 1995.* London: H.M. Stationery Office.

Summers, G.F. (1970). *Attitude Measurement.* Chicago: Rand McNally.

Sudman, N. and Bradburn, N. (1983). *Asking questions: a practical guide to questionnaire design.* London: Jossey-Bass Publishers.

Swann, M. (1985). *Education for all: the report of the committee of inquiry into the education of children from ethnic minority groups.* Command 9453. London: H.M. Stationery Office.

Taylor, N. (1994). The primary-secondary transition: a case study of a Midlands comprehensive school. Education Today 44 (1), pp.30-34.

Tobin, T. (1997). Gender equity and the enacted science curriculum. In: Parker, L., Rennie, L. and Fraser, B. *Gender, Science and Mathematics: shortening the shadow.* Dordrecht, The Netherlands. pp. 119-127.

Thomas, K., ed. (1971). *Attitudes and Behaviour.* Harmondsworth, Middx: Penguin Modern Psychology Readings.

Thompson, R.A. (1992). Development changes in research risk and benefit. A changing calculus of concerns. In: Stanley, B. and Sieber, J.E. eds. (1992) *Social research on children and adolescents: ethical issues.* London: Sage.

Thurstone, L.L. and Chave, E.J. (1929). *The measurement of attitudes.* Chicago: University of Chicago Press.

Tymchuk, A.J. (1992). Assent processes. In: Stanley, B. and Sieber, J.E., eds. (1992). *Social research on children and adolescents: Ethical issues.* London: Sage.

Tizard, B., Burgess, T., Francis, H., Goldstein, H., Young, M., Hewison, J. and Plewis, I. (1980). *15,000 hours: a discussion.* London: Institute of Education, University of London.

Tutchell, E., ed. (1990). *Dolls and dungarees: gender issues in the primary school curriculum.* Buckingham: Open University Press.

Walden, R. and Walkerdine, V. (1985). *Girls and mathematics: from primary to secondary schooling.* Bedford Way Papers No.9. London: Institute of Education.

Walkerdine, V. and Lucey, H. (1989). *Democracy in the kitchen: Regulating mothers and socialising daughters.* London: Virago.

Warren, N. and Jahoda, M., eds. (1973). *Attitudes - selected readings. 2nd Edn.* Harmondsworth, Middx: Penguin Books Ltd.

Watts, M., Gould, G. and Alsop, S. (1997). Questions of understanding: categorising pupils' questions in science. *School Science Review* 79 (286), pp 57 – 63.

Weidling, R. (1985). *Research in school effectiveness - a discussion paper.* Slough: N.F.E.R.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching* 32, pp. 387-398.

Whyte, J., Deem, R., Kant, L. and Cruickshank, M. eds. (1985). *Girl friendly schooling.* London: Methuen.

Wiggins, D. and Wright, L (2000). *Five Year Study Summary of the first four years 1996-1999.* Herts: Association for Science Education.

Wolpert, L. (1994). Science makes the world go round. *The Sunday Times,* 20th March.

Woolnough, B.E. (1991). *The making of engineers and scientists; factors affecting schools' success in producing engineers and scientists.* Oxford: Oxford University Department of Education.

Woolnough, B.E. (1994a). Why students choose physics, or reject it. *Physics Education* 29 (6), pp. 368-374.

Woolnough, B.E. (1994b). Factors affecting students' choice of science and engineering. *International Journal of Science Education* 16, pp. 659-676.

Woolnough, B.E. (1994c). *Effective Science Teaching.* Buckingham, Open University Press.

Woolnough, B.E (1995). School effectiveness for different types of potential scientists and engineers. *Research in Science and Technological Education* 13, pp.53-56.

Woolnough, B.E. (1996). Changing pupils' attitudes to careers in science. *Physics Education* 31 (5), pp. 301-308.

Woolnough, B.E. (1997). Motivating students or teaching pure science? *School Science Review* 78 (285), pp. 67-72.

Wragg, E.C., Haynes, G.S., Wragg, C.M. and Chamberlin R.P. (2000). *Failing Teachers?* London: Routledge.

Young, S. (1992). The gulf between Professor Boffin and Joe Public. *The Observer,* 2nd February, p. 4.

Youngman, M.B. and Lunzer, E.A. (1977). *Adjustment to Secondary Schooling. Joint Research Project.* Nottinghamshire County Council and Nottingham University. Nottingham: University of Nottingham.

Appendix 2.1

Summary of Proposals for Profile Components and Attainment Targets
(Department of Education and Science, 1988, pp. v and vi)

Profile Component	Attainment Target	Title
Knowledge and Understanding	1	The Variety of Life
	2	Processes of Life
	3	Genetics and Evolution
	4	Human Influences on the Earth
	5	Types and Uses of Materials
	6	* Making new Materials
	7	* Explaining how Materials Behave
	8	Earth and Atmosphere
	9	Forces
	10	Electricity and Magnetism
	11	Information Transfer
	12	Energy Transfer
	13	* Energy Resources
	14	Sound and Music
	15	Using Light
	16	The Earth in Space
Skills of Exploration and Investigation	17	Doing
	18	Working in Groups
Communication	19	Reporting and Responding
	20	Using Secondary Sources
The Study of the Role of Science and Society "Science in Action"	21	Technology and Social Aspects
	22	The Nature of Science

* not for KS1 and KS2

Appendix 2.2

Most appropriate learning experiences in science: suggested selection criteria.
(National Curriculum Council, 1989a, p.95)

The experiences should enable pupils to:

- *develop scientific strategies and skills;*
- *develop attitudes appropriate to working scientifically;*
- *develop basic scientific concepts;*
- *reach a satisfactory outcome;*
- *apply scientific ideas to real-life problems, including those which require a design and technological solution;*
- *work co-operatively and communicate scientific ideas to others;*
- *develop an understanding of the relationship of scientific ideas to spiritual, ethical and moral dilemma;*
- *discuss the way in which scientists work.*

The experience should:

- *stimulate curiosity;*
- *relate to the interests and everyday experiences of the pupils;*
- *appeal to both boys and girls and those of all cultural backgrounds;*
- *help pupils to understand the world about them through their own mental and physical interaction with it;*
- *involve the use of simple and safe equipment and materials;*
- *involve resources and strategies available to teachers*
- *contribute to a broad and balanced science curriculum, bearing in mind experiences already selected.*

Appendix 3.1

The Girls into Science and Technology (G.I.S.T.) project: Kelly (1986)

Key points relevant to the research study:

- Using questionnaires, 1300 pupils' attitudes to various aspects of science were sought on arrival at comprehensive school in September 1980 and again 2½ years later.

- The Science Curiosity questionnaire contained four sub-scales and sought to elicit the pupils' views (on a 3-point scale) on curiosity about physical science, nature study, human biology and 'spectacular'[1] science.

- The Image of Science questionnaire, also using 4 sub-scales, sought the pupils' agreement to a series of statements on the pupils' views of science as a force for 'good' or 'evil' in the world, personal liking for science, image of the scientist as a person and the degree to which science was stereotyped as a 'male' subject. Attitude changes were examined using paired *t*-tests, correlations and analysis of variance and co-variance.

- The pupils in both 'action' and 'control' schools[2] lost interest in learning about most aspects of science (particularly nature study and 'spectacular' science) and, by the end of the study, the pupils' interest in learning about science was quite strongly related to their views on science and scientists (see Chapter 1).

- The difference between the boys' and the girls' (age 11/12) personal liking for science was small but, during the following 18 months, the gap widened as the girls' scores decreased more rapidly than those of the boys.

- The pupil's gender and initial attitude to science were strongly related to their attitude to science three years later[3] (the type of school and I.Q. score had weaker effects).

- Gender differences did not change significantly over the period of study but the girls' scores were significantly higher $(p<0.001)$ for nature study, interest in human biology (and the social implications of science, image of scientists, and that science was exclusively a boys' subject).

- Kelly (p.411) also commented that, in many ways, the children's attitudes were 'remarkably stable' over the two and a half years of the study and in some ways this was disappointing "as it implied that children's basic notions about science are formed by the media and other informal agencies, not by professional science teachers."

[1] animals in the jungle, volcanoes, earthquakes, acids and chemicals (Whyte et al. 1985, p.80)

[2] Although the intervention policy actually affected both the boys' and girls' attitudes to the same extent (Kelly, 1986, p.405), the policy was found to be most effective for the middle class and/or academically able girls.

[3] The pupil's social class and whether or not the pupil was in an intervention school had little apparent effect on the final attitudes.

- There was a decline in interest in physics over the two and a half year of the study, the boys demonstrating more favourable attitudes than the girls to the physical sciences *($p<0.05$)* and to 'spectacular' science. In general, the girls' initial enthusiasm for the physical sciences was low and it did not increase by the end of the study. The complexity of physics and chemistry often had a discouraging effect on girls.

- Whilst the girls' enthusiasm for science as a whole was high on entry to the secondary school, the decline in enthusiasm by the end of the study was in line with the girls' lack of curiosity for the physical sciences.

- Pupils who had positive attitudes to learning about science, and who held positive stereotypes of science at the start of their secondary education, generally maintained these attitudes until their third year in secondary school (Year 9).

- The correlation coefficients between personal liking of science and curiosity about physical science showed the greatest change during the two and a half years of the study (for the boys it increased from 0.30 to 0.58 and, for the girls, the increase was 0.24 to 0.49).

- Interest in physical science appears to be a measure identified by most researchers as a good indicator of pupil interest in the sciences in general.

- The pupils' curiosity for science and personal liking for science scores were not related to the I.Q. scores of the children as they entered secondary school but, by their third year of secondary education, the more able pupils exhibited a greater interest in learning about science; this was much more noticeable for the girls (particularly regarding the physical sciences) than for the boys. It was suggested (p.411) that this may be the first stage in the process whereby children sort out their subject choices to fit their personalities and only "extremely able" girls continue to study science.

- At both the beginning and end of the study, there were large gender differences in the pupils' perception that science was 'masculine' (and hence not an appropriate subject for study by girls) and these differences seemed to be re-inforced by the classroom environment (see Kelly, 1985 and Whyte, 1984).

- The project had more success in altering pupils' attitudes than their actual subject choices and Kelly commented (p.407) that it may be that "with developing maturity, pupils become more aware of the rhetoric of equal opportunity, without this necessarily affecting their own behaviour." This supported the observations of Whyte et al. (1985) who suggested that it was easier to change attitudes than to change behaviour.

Appendix 3.2

The Assessment of Performance Unit (A.P.U.) studies (Department of Education and Science, 1986)

Key points relevant to the research study:

- Between 1980 and 1984, the APU science monitoring programme conducted 5 annual surveys (using short-answer, extended response and multiple choice formats) of about 5,000 pupils at each of three ages (11,13 and 15).

- Although by the end of the study the ratio of 15-year old boys: girls opting to take up physics was less than 3:1 compared with a ratio of 5:1 ten years earlier, the gender gap remained "uncomfortably large" (p.6).

- A preference for physics was shown by the boys (it was suggested that this may have been due, at least in part, to the different practical and play experiences to which young boys and girls were exposed - see Whyte, 1985 and Clarricoates, 1978).

- Consistent, statistically significant differences were found between boys and girls at ages 11, 13 and 15 on their knowledge of applying physics concepts but no consistent gender differences were detected on the application of biology concepts[4] at any of these ages (see Johnson and Murphy, 1986).

- The boys, compared with the girls, produced significantly higher group mean scores on physics tests and it was noted that this 'physics performance gap' increased with age (p.10). The boys[5] produced higher average scores compared with the girls on more than 90% of the questions designed to elicit pupils' views on the application of physics concepts; for half of the questions, the differences were statistically significant.

- The girls consistently produced higher performance scores than the boys on the practical observation tests (it was suggested that this might explain why the majority of girls who do proceed with the sciences tend to prefer biology, with its emphasis on detailed observation techniques, rather than physics or chemistry).

- It was suggested that the boys' early experiences of, for example, a wider range of measuring instruments (see also Kahle and Lakes 1983; Smail and Kelly, 1984a) might generally provide a broader base from which some of the concepts of physics could be more easily accepted.

- There were distinct differences between the boys' and the girls' early scientific experiences and interests and these differences continued through to their teenage hobbies and activities.

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[4] Comber and Keeves (1973) suggested that, although the gender gap in attainment in the three main sciences was least in biology, the boys still had higher scores.

[5] When grouped by ability, there were more boys than girls in the higher ability groups at age 15; in the lower ability groups the balance was more even (for all three age groups).

- Referring to secondary age girls, a tenuous link was made that the negative attitudes of the girls may, to some extent, relate to the lower achievement of girls in science and mathematics in the early years and that this, in turn, might be linked with the "intrinsic differences between male and female intellectual capabilities" (p.6). It was suggested that it was the early socialisation experiences of young infants (and the adoption of gender-specific roles) which might lead to differences in their interests, motivation and achievements in later years.

- There were gender differences in the "out-of-school" activities - the boys engaging more than the girls in 'tinkering' activities (according to the authors this might explain their greater confidence in formal practical work in the secondary school). 'Role expectations' and job aspirations were noticeably different for the boys and the girls.

Aspects of Science Education in English Schools: The Second[6] International Mathematics and Science Survey (Keys, 1987)

Key points relevant to the research study:

- The data were collected by questionnaires in 1984 from 10-year-old and 14-year-old pupils[7] (as well as pupils in their last year of school and at Colleges of Further Education) as part of the Second International Science Study. Standardised tests were used to collect data on pupils' achievement as well as on a wide range of "out-of-school" and "in-school" factors. The study aimed to complement the APU surveys by examining factors associated with favourable attitudes to science.

- The pupils' interest in science declined as they progressed through the secondary school. Although the majority (59%) of 14-year old students found science lessons "interesting", this was lower than the percentage (73%) of 10-year-olds who reported that their science lessons were "interesting" - only 13% of 14-year-olds felt that science lessons were <u>never</u> interesting.

- Sixty-four per cent of the 10-year-olds, compared with 57% of the 14-year-olds, reported that science was 'enjoyable'. (About two-thirds of the 14-year-olds reported that their teachers sometimes, or often, explained how the science they learned was relevant to their own lives).

- Boys showed significantly *($p<0.01$)* more favourable attitudes, than the girls, to science (as measured using a rating scale on 'beneficial aspects of science to society') at age 14 but, at age 10, no such differences were found. Keys (1987, p.144) commented that it was "interesting to speculate on possible causes"[8].

- For the 14-year-olds, positive attitudes towards the subject (i.e. a liking for science) and the perceived ability in science, showed a moderate positive correlation with the pupils' achievement in science (as shown by high test scores); there was a weaker association between these measures for the 10-year-old pupils.

- Twenty-nine per cent of 10-year-olds (*$n=3673$*) and 24% of 14-year-olds (*$n=3061$*) liked science more than other subjects; 46% of the 10-year-olds and 53% of the 14-year olds liked it about the same as other subjects (p.122).

- Eighty-five per cent of the 10-year-olds, and almost all of the 14-year-olds, 'sometimes' or 'often' copied the teacher's notes from the board (p.133).

[6] The Third International Study was conducted in 1995 (Keys et al., 1996a: Keys et al., 1996b; Harris et al., 1997; Keys et al., 1997).
[7] 3802 pupils and 3176 pupils respectively completed at least one questionnaire.
[8] It could be that, at age 10, the pupils had relatively little exposure to 'science' and were simply unaware, at this age, of the wider issues.

- A low to moderate correlation was found between the lack of difficulty (facility) of science and test scores (performance) and a low to moderate positive partial correlation (0.13 to 0.33) between science achievement and the 'facility of science' measures.

- About two-thirds[9] of the 10-year-old children found science to be relatively easy[10] and approximately half of the 14-year-olds (compared with about one-third of the 10-year-olds) agreed with the statements 'Science is a difficult subject' and 'there are too many facts to learn in science' (p.120).

- Fifty-three percent of the 14-year-olds agreed that science was difficult when it involved handling calculations, but only 12% agreed it was difficult when it involved handling apparatus.

- The 10-year-old pupils found biology easier than physics. For the 14-year-olds, the chemistry was seen as the most difficult and the physics was the easiest[11].

- There was no significant gender difference in the responses of the 10-year-old pupils to their difficulty with science but the 14-year old girls found it harder than the boys of the same age ($p < 0.01$).

- Practical work was more common with 14-year-olds; two thirds reported that they did practical "often" and one-third reported they did practical "sometimes", compared with one-third "often", half "sometimes" (and almost 20% "never") for the 10-year-olds[12]. The emphasis was not just on amount of group, or individual, practical work but on how it was introduced and whether it was student-initiated or teacher-directed and whether it was group or individual work. For the 14-year-olds, Keys noted that practicals were quite "a formalized activity" (p.114).

- Achievement was positively associated with the perceived amount of practical work taking place in lessons (p.107). Weak positive associations were demonstrated between science achievement and an interest in taking up a career in science (p.126).

- The issues on which the boys out-performed the girls by the greatest amount were those related to "out-of school" interests which were generally favoured by the boys (p.151).

- For 10-year olds, the block of predictor variables concerned with the composite measure of home background (17.5%) and family size (1.7%) explained 19.2% of the variation in science achievement of the students. There was a negative correlation between family size and science achievement.

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[9] In the Third study (1995) 46% of the Year 5 children agreed that "science is an easy subject" (Harris et al., 1997, p.84).

[10] Based on a 'facility of science' score which also included items concerned with interest and enjoyment.

[11] Keys referred (p.67) to the A.P.U. findings in which a similar trend in the studies of the performance of 13-year olds was identified (see Khaligh et al., 1986).

[12] Harris et al. (1997), reporting on the findings of the Third International Mathematics and Science Study, reported that, in 1995, virtually all the Year 5 pupils did practical in science lessons and that practical activities took up at least 75% of the curriculum time spent on science.

- The proportion of 10 to14-year-olds whose fathers were in non-manual occupations was 30-40% (p.38). For 'A' level science students 47% of mothers and 58% of fathers had continued their education (not necessarily in science) beyond the school leaving age and 21% of the mothers and 37% of the fathers of these pupils had degrees or professional qualifications.

- A comparison of simple and partial correlation coefficients showed that the positive associations between students' attitudes and their achievement were almost independent of home background[13] (p.80). For the 10-year olds, however, the 'home based' factors accounted for 17.5% of the contribution towards their science achievement and Keys noted (p.66) that the higher than expected performance scores of the 10-year-old pupils suggested that they had learnt "a great deal of science outside school."

- For the 14-year-olds, the home block predictor variables (the composite measure of home background, 20.2%, having a computer at home, 2.4%, and family size, 0.8%) explained 23.4% of the variation in science achievement. This is in almost exact agreement with the findings of Comber and Keeves (1973) in the First International Study. There was a negative correlation between family size and science achievement.

- Referring to the studies reviewed by Weidling (1985), Keys (pp.79-80) commented that in the majority of the studies only 1-3% of the variation in students' *achievement* over and above the variation explained by home and student differences was attributable to school and teaching factors. Home background, rather than school or teaching factors, was more important in determining educational achievement in general; they might be responsible for 50-70% of the variation in students' achievement (but not specifically achievement in *science*).

- The contribution of the home block of variables to the achievement of 'A-level biology, chemistry and physics students was much less (3.8%, 6.8% and 2.0% respectively).

- It was assumed that the younger age groups would not be able to answer questions on their parents' educational background and so the 'home background measure' was not the same for all the age groups. Preliminary trials had demonstrated that, unlike the 'A' level students, the 14-year-olds were not aware of the length of their parents' education or their professional qualifications and so the composite measure was formed from measures of both parents' occupations, the students' estimate of the number of books in the home and the newspaper reading scale. For the 10-year olds the fathers' occupations measure was excluded from the study (more than 20% of the data was missing) and no attempt was made to elicit information directly from the parents.

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[13] In the First I.E.A. study it had been suggested that home background factors, whilst important, might explain only 20% of the variance in science achievement in 10 to 14-year-olds (Comber and Keeves, 1973).

- According to Keys (p.81), most of the studies on the contribution of various school-related factors to pupils' achievement have been contradictory; most of the evidence (suggesting various percentage contributions from 0-20%) has come from small scale studies in which the data was collected by classroom observation as well as, or instead of, the use of questionnaires. She noted that many of the factors associated with school achievement were due to effective management and positive leadership by the Head which could not easily be measured in large scale surveys.

Appendix 3.4

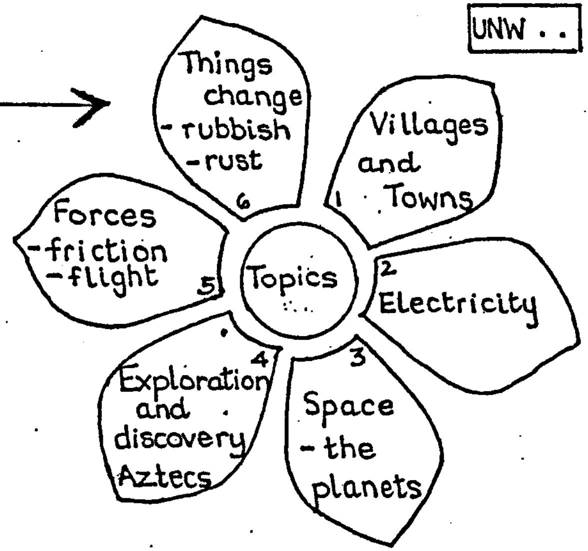
Keeves' paradigm for the study of educational environments (Keeves, 1975)
Antecedent conditions

Year 5 questionnaire

UNW . .

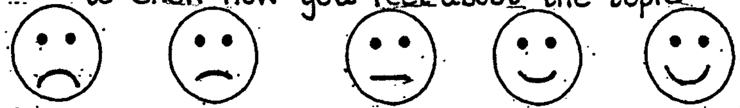
What do you like doing most?

In Year 5 you have studied the topics shown here →



For each of the 6 topics shown on the chart below

a) put a tick ✓ in just one of the boxes to show how you feel about the topic



b) in the last column try to write a few words about why you liked - or disliked - the topic

TOPIC	How I felt about the topic					I liked - or disliked - the topic because......
	disliked a lot	didn't like very much	alright O.K	quite liked	liked a lot	
1. Villages and Towns						
2. Electricity						
3. Space - the planets						
4. Exploration						
5. Forces						
6. Things change						

Page 1

Year 5 questionnaire

UNW--

2. Name the subjects, or activities, which you like doing most <u>in school</u>:

3. Do you enjoy investigating things? Tick one of the boxes below:

not much ☹	sometimes maybe 😐	quite a lot ☺
☐	☐	☐

4. In the table below:

(a) List any interests (including hobbies and activities) which you have <u>outside school</u>.

(b) Put the name (or names) of the people who help you most with these interests.

(c) Do any of these interests help you with your school work? If so, can you explain this in column (c).

(a) Interests (including hobbies and activities)	(b) I get help from:	(c) My outside school interests/hobbies/activities help me with:	because:

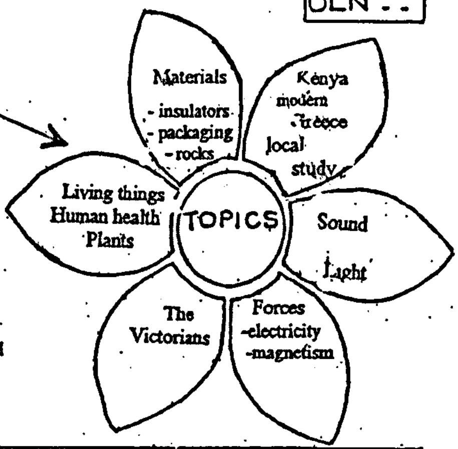
THANK ☺ YOU

Page 2

Appendix 4.2

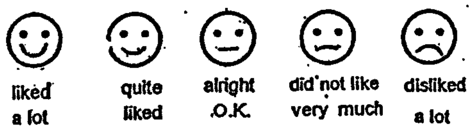
Year 6 questionnaire

OLN ..



In Year 6 you have studied the topics shown here

1. For each of the topics on the chart below, put a tick (✓) in just one of the boxes to show how you feel about each topic:



TOPIC	How I felt about the topic					Any comments about the topic
	☺	☺	😐	😕	☹	
Kenya Modern Greece Local study						
Sound and light						
Forces: Electricity and magnetism						
The Victorians (history)						
Living things: Human health; plants						
Materials: Insulators; packaging Soils and rocks						

2. In school, which subject do you like doing most?..

Can you explain why you like this subject?..

Outside school, what are your main interests, hobbies and activities?

....

3. Do you like investigating things?

(tick one of the boxes)

	quite a lot		sometimes		not much

please turn over→

Year 6 questionnaire

4. Compared with other subjects, how do you feel about science?
(tick one of the boxes)

☐	I like it a lot
☐	I quite like it
☐	I neither like it nor dislike it
☐	I don't like it very much
☐	I dislike it

Can you explain your choice ?

....

....

5. Compared with last year, do your think your science lessons have been:

☐	more interesting
☐	about the same
☐	less interesting

Can you explain why ?

....

....

6. Which of these comments best describe how <u>you</u> feel about science:

☐	I find it very easy
☐	I find it quite easy
☐	I find it neither easy nor difficult
☐	I find it quite difficult
☐	I find it very difficult

Can you explain your answer?

....

....

7. Do you know what a "scientist" does?
(tick one of the boxes) ☐ Yes ☐ No

If you ticked "Yes"
Can you explain what he /she does?..

8. Might you like to be a scientist one day?
(tick one of the boxes) ☐ Yes ☐ No

If you do <u>not</u> want to be a scientist, have you any ideas about what you might like to be?

....

9. Do you think science lessons will be <u>different in your new school</u>?
(tick one of the boxes) ☐ Yes ☐ No

If you ticked "Yes" what do you think might be different about them?

....

....

10. Can you describe how do you feel about going to your new school?
(What are you looking forward to? Does anything worry you?)

....

Thank ☺ you

Appendix 4.3

Year 7 questionnaire

9. Answer **either** (a) **or** (b) :
   (a) If **Science** <u>is</u> your **favourite** subject, explain (briefly) what you <u>like</u> about it?.........................
   ....
   (b) If **Science** <u>is not</u> your **favourite** subject, explain (briefly) what you <u>don't</u> like about it?............
   ....

10. During **Year 7** you have covered eight **modules** in **Science.** In the chart below, put a tick (✓) <u>in one box for each module</u> to show how you feel about the module. In the last column, put any comments about why you liked, or disliked, each of the modules.

MODULE	ATTITUDE <like ....dislike>					COMMENTS
	☺	😀	😐	😟	☹	
Basic skills						
Ecosystems						
Processes of Life						
Space						
Electricity and Magnetism						
Forces and Energy						
Light and Sound						
Materials						

11. Please tick (✓) ONE of the boxes below which describes how you feel about **Investigations**?

I enjoy investigations/practical work	
I neither like, nor dislike, investigations/practical work	
I don't enjoy investigations/practical work	

12. Please tick (✓) ONE of the boxes below which best describes what you think about **Science** in **Year 7** <u>compared with</u> **Science** in **Year 6.**

Science in Year 7 is **more** interesting than in Year 6	
Science in Year 7 is **no more, no less** interesting than in Year 6.	
Science in Year 7 is **less** interesting than in Year 6	

13.

Please tick (✓) ONE of the boxes below which best describes how <u>you</u> feel about asking your science teacher questions		Please tick(✓) ONE of the boxes below which <u>you</u> think best describes your relationship with your science teacher	
I feel happy about it, it doesn't worry me		I think I get on well with him/her	
I don't feel happy, or unhappy, about it		I have no views about it	
I feel unhappy about it, it worries me		I don't think I get on well with him/her	

14. What career/job might you like to have when you leave school? ....
(if you are not sure yet, write "don't know")

******* ***Thank you for your help*** *******

Year 8 questionnaire

Year 8 Questionnaire **Name.......................................Tutor Group ....**

1. In the table below please put a tick (√) in ONE of the boxes to show which subject area you have enjoyed studying most during Year 8:

Design/technology		Art		Humanities	
Science		German		French	
Mathematics		Performing arts		English	

2. What things are <u>good</u> about your **favourite subject?** ....

....

3. Please put a tick (√) in ONE of the boxes below. Was your **favourite subject choice in Year 8** the same as in **Year 7?**

Yes		No		Can't remember	

4. In the table below tick (√) ONE box <u>in each row</u> which best describes your feelings about Science

	strongly agree	**agree**	**neither agree nor disagree**	**disagree**	**strongly disagree**
1. Science is interesting					
2. We should do more practical work in science					
3. Science is boring					
4. We learn new things in science each year					
5. Science is difficult to understand					
6. My science teacher is quite helpful					
7. We study the same things in science each year					
8. We have to do a lot of writing in science					

5. Please tick (√) ONE of the boxes below which best describes how you feel about your **performance in Science during Year 8**

I think I'm very good at it	
I think I'm quite good at it	
I think I'm about average at it	
I think I'm quite poor at it	
I think I'm very poor at it	

please turn over->

Year 8 questionnaire

6. Complete the following:
   Three things I <u>like</u> about **Science** lessons are 1)..
   2)..3)..
   Three things I <u>don't like</u> about **Science** lessons are 1)...
   2).. 3)..

7. During **Year 8** you have studied **nine modules** in **Science** covering the sciences of *biology, chemistry and physics.* In the chart below, put a tick (√) in **ONE** box <u>for each group of modules.</u> In the last column, put any comments about why you liked, or disliked, any of the modules

MODULE	ATTITUDE SCORE <like				dislike>	COMMENTS
	5 ☺	4	3	2	1 ☹	
Biology: **Body Maintenance; Understanding Ecosystems; Life Cycles**						
Chemistry: **Classifying Materials; Changing Materials; Patterns of Behaviour**						
Physics: **Electricity/Magnetism; Forces and Energy; Light and Sound**						

8. Please tick (√) **ONE** of the boxes below which best describes what you think about **Science in Year 8** compared with **Science in Year 7:**

Science in Year 8 is **more interesting** than in Year 7	
Science in Year 8 is **no more, no less interesting** than in Year 7	
Science in Year 8 is **less interesting** than in Year 7	

9. Please tick (√) **ONE** of the boxes below which best describes how you feel about **investigations** and **practical work:**

I enjoy investigations/practical work	
I neither like, nor dislike, investigations/practical work	
I don't enjoy investigations/practical work	

10. What are your main **interests, hobbies and activities** outside school?..
    ....

11. What **career/job** might you like to have when you leave school?.......................................

***** ☺ **Thank you for your help** ☺ *****

Year 9 questionnaire

Year 9 Questionnaire **Name**...**Science Group**..........

In Year 9 you have studied the following modules in science

Biology: Body Maintenance **(BM)** Ecosystems **(ES)** Variety of Life **(VL)**
Chemistry: Chemical Patterns **(CP)** Chemicals and Earth **(CE)** Materials Chemistry **(MC)**
Physics: Electricity and Magnetism **(EM)** Forces and Energy **(FE)** Light and Sound **(LS)**

1. In the table below please place a tick (✓) in **ONE** column which you think best matches the descriptions in a) to d). Please tick **ONLY ONE** box in each row.

This module→	BM	ES	VL	CP	CE	MC	EM	FE	LS
a) was the **most interesting**									
b) was the **least interesting**									
c) was the **most difficult to understand**									
d) was the **easiest to understand**									

2. Could you comment on your answers in a) to d) above?

a) This module was the **most interesting** because ....

b) This module was the **least interesting** because ....

c) This module was the **most difficult to understand** because ....

d) This module was the **easiest to understand** because ....

3. In the table below please place a tick (✓) in any columns which you think match the descriptions in e) to i). You may tick more than **ONE** box in each row if you wish.

These modules →	BM	ES	VL	CP	CE	MC	EM	FE	LS
e) covered a lot of what we did in Year 8									
f) had too much practical work									
g) didn't have enough practical work									
h) had about the right balance of practical and written work									
i) had too much written work									

4. Please tick (✓) ONE of the boxes below which best describes what you think about **Science in Year 9** compared with **Science in Year 8**

Science in Year 9 is **more** interesting than in Year 8	
Science in Year 9 is **no more, no less** interesting than in Year 8	
Science in Year 9 is **less** interesting than in Year 8	

Comments:

....

5. Of the subjects (other than P.E.) which you have studied this year, which is your favourite?..........................

Year 9 questionnaire

SATS

6. How did your SATS results compare with your expectations?
please tick ✓ one box

better than expected		about the same		lower than expected	

7. **Which revision materials** did you find the most useful for your SATS? Please put a tick ✓ in the appropriate boxes in the table below:

Revision aid	**not used**	**excellent**	**very helpful**	**satisfactory**	**not very helpful**	**no help at all**
a. Year 9 Textbook (Starting Science 3)						
b. Another textbook e.g..................						
c. Your notes from class lessons						
d. Revision sessions in class *(if you were away, write "absent")*						
e. Help from parents, relatives or friends						
f. Other (e.g.videos or CD roms) e.g.						

8. Give TWO ways in which you think <u>you</u> could **improve your revision strategy**

1... 2...

INVESTIGATIONS

9. Please tick (✓) ONE of the boxes below which describes how you feel about **investigations?**

I enjoy investigations/practical work	
I neither like, nor dislike, investigations/practical work	
I don't enjoy investigations/practical work	

CAREERS/JOBS

10. What career/job might you like to have when you leave school? ....
(if you are not sure yet, write "don't know")

Thank ☺ you

Appendix 4.6

Questions on parental background in science

Extract of some questions on science and parental background
(issued to Year 7 at a non-participating secondary school)

(Following introductory questions on previous primary school(s))

1. What do you think 'science' is about?

2(a). Last year, how did you feel about science lessons compared with other school subjects ?

Underline ***one*** *answer only.*

I liked it

A **lot more** than/**more** than/ **about the same** as/ **less** than/a **lot less** than other school subjects

2(b) What were the things (if any) that you **liked** about science lessons?

2(c) What were the things (if any) that you **disliked** about science lessons?

3(a) Would you like to be a 'scientist' one day? (*underline your answer)* **Yes/No**

3(b) Different sorts of scientists study different things. If you answered **'Yes'** in 3(a), which bit of science you would like to study and why?

4(a) Is your father a scientist?

(*underline your answer)* **Yes / No /Don't know**

4(b) If you answered **'Yes'** to 4(a), is he working as a scientist now?

(*underline your answer)* **Yes / No /Don't know**

4 (c) If you answered **'Yes'** to 4(a), how could you describe what he does?

4(d) If you answered **'Yes'** to 4(a), does he encourage you to be a 'scientist' when you leave school?

(*underline your answer)* **Yes / No**

5(a) Did your father go to College or University after he left school?

(*underline your answer)* **Yes / No / Don't know**

5(b) If you answered **'Yes'** to 5(a), did he study science?

(*underline your answer)* **Yes / No / Don't know**

5(c) If you answered **'Yes'** to 5 (b), do you know which science(s) he studied?

He studied ....

6 (a) Is your mother a scientist ?

(*underline your answer)* **Yes / No / Don't know**

6 (b) If you answered **Yes** to 6(a), is your mother working as a scientist now ?

(*underline your answer)* **Yes / No / Don't know**

6 (c) If you answered **'Yes'** to 6(a), how could you describe what she does?

6(d) If you answered **'Yes'** to 4(a), does she encourage you to be a 'scientist' when you leave school?

(*underline your answer)* **Yes / No**

7(a) Did your mother go to College or University after she left school?

(*underline your answer)* **Yes / No / Don't know**

7(b) If you answered **'Yes'** to 7(a), did she study science?

(*underline your answer)* **Yes / No / Don't know**

7(c) If you answered **'Yes'** to 7 (b), do you know which science(s) she studied?

She studied ....

8(a) Do you have any brothers or sisters older than you?

(*underline your answer*) **Yes / No**

8(b) If you answered '**Yes**' to 8 (a), are any of these brothers or sisters scientists or have they said they would like to be scientists one day?

(*underline your answer*) **Yes / No**

8(c) If you answered '**Yes**' to 8 (a), have any of these older brothers and sisters encouraged you to develop an interest in science?

(*underline your answer*) **Yes / No**

9(a) Other than parents and brothers and sisters, do you have any other relatives who are scientists?

(*underline your answer*) **Yes / No / Don't know**

9(b) If you answered **Yes** to 9(a) how could you describe what the relative(s) does/do?

9(c) If you answered **Yes** to 9(a) do any of these relatives encourage you to be a 'scientist' when you leave school?

(*underline your answer*) **Yes / No**

10. Has anyone discouraged you from being a 'scientist'? If so, can you explain how they put you off?

Thank you ☺ for your help

Example of format for Year 6 "mini-essay"

XLI 19

School

Have you enjoyed your Science work in Miss class?

In the space below, can you write about some of the things which you have done in your Year 6 **Science** lessons? Which things did you find most interesting? If you can, try to explain <u>why</u> you think they were interesting and what you think you have learnt from those lessons.

Were there some things you did <u>not</u> like? Why? Let me know about those as well! Thank you ....

Mrs C M Jones

****

<u>Science in Year 6</u>

Science in year six has vitully been the same as year five. Space, Forces and energy and electricity are my best subjects. Space I like the best because I like ~~knokx~~ knowing about it. I also like electricity. We've been on a trip to Didcot Power Station and we learnt all about how to make electricity. I also like forces and energy because I like learning about gravity, upthrust and all the forces that go to all the things you do.
The worst thing I hate is Materials, thats all I don't like

Parental questionnaire (Year 6: 1996)

Questionnaire on Science **Pupil Code: XLI ( )**

Please tick (✓) ONE box: I am [MALE] [FEMALE]

A. *At primary school (or up to about age 11)*
Primary science includes nature study, environmental studies etc.

1. Attitudes
Please tick (✓) **ONE** of the boxes below which describes how **you** felt about **science** when you were at **primary** school:

	Liked **science** a lot
	Quite liked **science**
	Neither liked **science**, nor disliked it
	Cannot remember much about it
	Did not like **science** very much
	Disliked **science**

2. Investigations
Please tick (✓) **ONE** of the boxes below which describes how **you** felt about **investigating** things when you were at **primary** school:

	Liked **investigating** things
	Neither liked, nor disliked **investigating** things
	Cannot remember doing much **investigation**
	Disliked **investigating** things

Do you have any comments about your experiences of **primary** science?

B. *Secondary science (after age 11)*
*Secondary science includes **Chemistry, Physics and Biology***

3. Attitudes
Please tick (✓) **ONE** of the boxes below which describes how you felt, in general, about your **secondary science**:

	Liked **science** a lot
	Quite liked **science**
	Neither liked **science**, nor disliked it
	Cannot remember much about it
	Did not like **science** very much
	Disliked **science**

If you had a **preference** for **ONE** of the sciences (i.e. chemistry, physics or biology) at this stage, please state which one...........

4. "Tinkering" *
(a) When you were of **secondary** school age did you enjoy "tinkering" with things?
Please underline: **Yes** or **No**.
(b) If you underlined "**Yes**", could you give an example?

*exploring things to see how they are put together, or how they work.

please turn over ------>

Parental questionnaire (Year 6: 1996)

C. Science background

5. Length of study
Please tick (✓) **ONE** of the boxes below which applies to your study of science:

☐	Stopped studying **science** before age 16
☐	Studied some **science up to age 16** ("O"level GCE/CSE/GCSE etc)
☐	Studied science **up to age 18** ("A" level/Scottish Highers etc) Please underline the subject(s) you studied: **Chemistry** **Physics** **Biology** and/or other related science .... (e.g. zoology)
☐	Studied science **after age 18** (i.e. in higher education) Did you study **science** as part of a degree course? Please underline: **Yes** or **No** If you have underlined **"Yes"**, what was the main subject area of your degree (e.g. engineering)...........

Any comments (e.g. if you later returned to study science to gain more more qualifications, or just for interest)

6. Science at work
(a) Whether or not you are currently employed, what do you regard as your main job/occupation? ....

(b) Do you use your knowledge of science in your main job/occupation?
Please underline: **Yes** or **No**

7. Interest in science
Please underline **Yes** or **No** as appropriate

(a) Would you like to have studied *more* science? **Yes** or **No**

(b) Do you "tinker" with things around the home (e.g. in the kitchen, garden or garage?) **Yes** or **No**

If you underlined "Yes", does your (Year 6) child usually show an interest in what you are doing? Yes or No
If you underlined "Yes", could you give an example of this?

(c) Do you do anything together with your (Year 6) child which you think might particularly encourage his/her interest in science? **Yes** or **No**
If you underlined "Yes" could you give an example?

Thank you for your help

Schedule for semi-structured, tape-recorded interviews Year 5 (June/July 1995)

Hello ……………, thank you for helping me with this study – I hope you're not too disappointed about missing *(lesson)* for 10 minutes!

I should like to ask you *(name)* a few questions in connection with the questionnaire which you have filled in – you remember, the one about what you liked doing in school, and why you liked doing those things?

That's alright is it? Your name won't be put on the tape, just a number so that I can link anything which you tell me about now with what you've written on the questionnaire. I'll also be asking your parents soon about what they liked, or disliked, when they were at school and, maybe we'll see if there is any connection.

Do you like doing practical work? Maybe if your mum, or whoever looks after you, was really keen on doing practical things at school then maybe you are too?

Introductory chat re brothers, sisters, pets, things they like doing to build up a picture of family and activities, what goes on in the household etc.

1. Does your mum work outside the home at all?

   If yes………..Do you know what she does?

2. Do you talk to her about things in school?

3. Do you think she helps you with your school work in any way?

4. Is there anything you do with her, or that she helps you with, which might help you with science in school, for example?

5. What about your Dad *(or other male)*, does he take an interest in your school work?

6. Does he help you with school work in any way?

7. Do you watch him, or help him, with anything around the house/flat/garage or garden?

8. Do you think that watching him doing that /those thing(s) help you with anything you do in school? .... in Science for example?

10. Do any of the things which you see either of your 'parents' (*named alternatives if known)* doing make you think about what you might like to do when you leave school?

11. If your parents have jobs outside the home, do you know what they do?
(prompt if appropriate)

12. Is there anyone else in the family, or very close to you – a neighbour perhaps – who does things you might like to do? (*examples.........)*
If yes..............what do they do?

13. Does anyone in the family, or anyone you know, tell you "never be a *(examples of jobs)*" and then give you a reason why you <u>shouldn't</u> be one of those when you leave school? Do they try to put you <u>off</u> doing anything?
If yes...........what do you think about that?!

14. Do you know what engineers do?........... accountants?

15. Do you know what a scientist does?
If **yes............** Do you think you might want to be a scientist of some sort when you leave school?

16. Do you know the names of any famous scientists (living or dead)?

Conclusion.......appropriate closure and thanks for help

Appendix 4.10

Schedule for semi-structured, tape-recorded interviews Year 6

Hello, I'm just going to ask you a few questions. Do you remember talking to me this time last year?

Which lesson have you come from?

This year, have you liked science more, about the same or less than other subjects?

Can you explain this.......*if* ***more****, what's good about it?*

if less*, what's not good about it?*
how would you improve it?

Do you find your teacher helpful?

Do you find science easier, about the same, or more difficult than other subjects?

if more difficult*......why do you think this is?*

What do you think science is all about? What is 'science'?

Anything else?

Might you like to be a scientist one day?

What might you want to do when you leave school?

What is your favourite subject?
Discuss*.........can you explain what you like about it?*

How do you feel about going to .... (comprehensive school)?
Discuss*......worries/ expectations*

Have you already got some friends there?

I hope you enjoy it, I hope to meet up with you again next year. Thanks and closure.

Appendix 4.11

Schedule for semi-structured, tape-recorded interviews Year 7

Hello *(name)* do you remember that I said that last summer that I would come to see you in your new school?

I think Mr/Ms *(tutor)* has already told you that I'd be trying to find you before the end of term.

Can you remember what this is about? *(expand if necessary)*

1. Setting the scene/old friendships

a) Although you're now in your new school, do you still meet up here with any of your friends from (primary school)?

If yes how much? Quite a lot/ sometimes/never?

b) Have you made some new friends here? *(explore)*
c) Do you miss your old school and Mr/Ms *(name of Year 6 teacher)*?

2. Transfer: expectations and reality

a) Anyway, how do you feel about <u>this</u> school?
b) Do you remember some of the things you told me last years about what you thought it would be like?

If yes *Is it like you expected? In what way(s)?*
Is it different in any way from what you expected?

c) What's good about this school ?
d) Is there anything about this school which you really <u>don't</u> like?

If yes *Do you think anything could be done about these things to make them better?*
If yes *So what ideas do you have about this/these then?*

e) Did you choose this school, or did someone else just tell you this was where you were to come?
f) Generally, was the work in Year 7 as you expected? *(prompt if necessary)*
easier than/about the same as/harder than expected?
enjoyable/O.K./not very enjoyable?

3. Preferences, attitudes and performance

a) What is your favourite subject?
b) What is good about it?

4. Perceptions of performance in favourite subject

Do you think you are: good/ /O.K./ a bit weak in *(favourite subject)?*
discuss any comments on relationship between preferences and performance

5. Performance in science

What do you think about your performance in science?
Do you think you are: good/O.K./not so good at science?

If science is **not** favourite subject

a) How does *(favourite subject)* compare with science?
b) How do you feel about science?
c) What about investigations – do you like doing practical work?
d) Can you explain why you like *(favourite subject)* more than science?
(prompt if necessary……is there something about science you don't like? expand……)

If science **is** favourite subject

a) Can you explain why you prefer science to other subjects?
b) What is good about it?
c) Do you prefer any particular modules? (explain if necessary)
d) Do you like doing investigations/ practical work?
a lot/ sometimes/not much

6. Career choices

either

a) If science is **not** favourite subject

Do you know what you might like to be/do when you leave school?
If ***yes:*** *Why do you think you would like to do/be that? (explain)*
b) Would you like to be a scientist *(negative answer expected)*

or

If science **is** favourite subject

Do you think you would like to be a scientist?
If ***yes***: *Do you know what sort of scientist you would like to be? (explain)*
If ***no***: Have you any other ideas?

7. Parental influences

Is anyone in the family, or a close friend, encouraging you to be a(n) *(example of profession or trade)* or anything else at the moment?
If **yes:** Who? Do you think you might take his/her advice?

(Close)
Well many thanks for your help, it will be interesting to see in a few years to see what you decide to do……….I'll see you again next week *(for the questionnaires)*

Appendix 4.12

Semi–structured, tape-recorded interview schedule: Year 8

Welcome and introduction, re-call of Year 7 interviews........there will be rather fewer questions this time.

1.*Science lessons*
a)How have you felt about science lessons in Year 8, were they different in any way from those in Year 7 ?

If yes How different? Can you explain the difference? *(expand)*

If boring?.......why? what do you mean by 'boring' ?
repeating things? in the same depth, or at a different level?
interesting....why? what made them more interesting?
learning new things? why did you think it was interesting?
more difficult? anything in particular? vocabulary/words?

b) Is there any way science lessons could be improved/made even better?

2. *Relationship with the teacher(s)*
a) How have you got on with your teacher this year? Good/bad/O.K?
b) Does your science teacher help you if you have questions, or you don't understand things?

3. *Practical work*
How do you feel about practical work?
If positive response - would you like to do <u>more</u> practical work?
(explore reasons)

4. *Favourite subject*
a) What has been your favourite subject this year? *(for consistency check)*
can you remember, was that the same as last year?
b) What is particularly good about your favourite subject? *(explore)*
degree of difficulty? perceived performance? relationship with teacher?

5. *Outside interests*
At the moment, what sort of things do you like doing outside school? *(make suggestions)*
for consistency check with questionnaire

6. *Career plans*
Do you think you would like to be a scientist, or work in science, when you leave school?
If no What might you like to do?

Close
Thanks for co-operation etc. and closure.

Responses to parental questionnaires

School (class)	Number of responses (male parents)	Number of responses (female parents)	Total number of responses	Number of pupils in class[14]	Response as % of theoretical maximum*
OL (I)	9	9	18	12	75.0
OL (N)	6	6	12	11	54.5
OL (U)	11	11	22	14	78.6
Total (OL)	26	26	52	37	70.3
XL (D)	18	19	37	27	68.5
XL (I)	17	20	37	25	74.0
Total (XL)	35	39	74	52	71.2
UN (W)	13	14	27	32	42.2
Total (UN)	13	14	27	32	42.2
Total all classes	74	79	153	121	63.2

[14] In School OL, Years 5 and 6 were taught together in 3 classes (figures given are for Year 6 pupils)

**Mean attitude scores to physical science and biological science modules
Years 5 to 7**

1(i). Mean attitude scores to physical science modules

Group	**All pupils**			**Boys**			**Girls**			**Significance (2-tailed)**
	mean	**SD**	***n***	**mean**	**SD**	***n***	**mean**	**SD**	***n***	
Electricity and Magnetism ***Year 5***										
School UN pupils only	4.04	1.45	27	4.00	1.73	13	4.07	1.21	13	*t(25)=-0.125; p= 0.901*
Final cohort School UN pupils only	3.47	1.68	15	2.83	2.04	6	3.89	1.36	9	*t(13)=-1.208; p= 0.248* ***Mann Whitney Z=-0.926; p=0.354***
Year 6										
All pupils	3.34	1.06	102	3.58	0.93	50	3.12	1.13	53	*t(100)=2.263; p= 0.026**
School UN pupils only	3.78	1.01	27	3.85	0.90	13	3.71	1.14	14	*t(25)=0.332; p= 0.742*
Average for Schools OL and XL pupils	3.19	1.04	75	3.49	0.93	37	2.89	1.06	38	*t(73)=2.565; p= 0.012**
Final cohort	3.31	1.10	71	3.67	1.03	30	3.05	1.09	41	*t(69)=2.410; p= 0.019**
Final cohort School UN pupils only	3.67	1.11	15	4.00	0.89	6	3.44	1.24	9	*t(13)=0.944; p=0.363* ***Mann Whitney Z=-0.751; p=0.452***
Year 7										
Final cohort	3.46	1.14	71	3.90	1.03	30	3.15	1.13	41	*t(69)=2.881; p= 0.005***
Final cohort School UN pupils only	3.80	1.15	15	4.33	0.82	6	3.44	1.24	9	*t(13)=1.542; p=0.147;* ***Mann Whitney Z=-1.413; p=0.158***

** significant at the 0.05 level, p<0.05*
*** significant at the 0.01 level, p<0.01*
**** significant at the 0.001 level, p<0.001*

1(ii). Mean attitude scores to physical science modules

Group	All pupils			Boys			Girls			Significance (2-tailed)
	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*	
Forces and energy ***Year 5***										
School UN pupils only	3.42	1.65	26	3.69	1.65	13	3.15	1.68	13	*t(24)=0.825; p= 0.418*
Final cohort School UN pupils only	3.00	1.77	15	3.33	1.86	6	2.78	1.79	9	*t(13)=0.580; p=0.572* ***Mann Whitney Z=-0.858; p=0.391***
Year 6										
Not studied										
Year 7										
Final cohort	3.20	1.17	70	3.55	1.12	29	2.95	1.16	41	*t(68)=2.139; p= 0.036**
Final cohort School UN pupils only	3.57	0.85	14	4.00	0.00	5	3.33	1.00	9	*t(12)=1.464; p= 0.169* ***Mann Whitney Z=-1.780; p=0.075***
Space ***Year 5***										
All pupils	3.78	1.22	102	3.76	1.25	50	3.81	1.19	52	*t(100)=-0.197; p=0.844*
Final cohort	3.90	1.19	71	3.97	1.19	30	3.85	1.20	41	*t(69)=0.395; p= 0.694*
Year 7										
Final cohort	3.66	1.26	71	3.83	1.18	30	3.54	1.32	41	*t(69)=0.977; p= 0.332*

**** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

1(iii). Mean attitude scores to physical science modules

Group	All pupils			Boys			Girls			Significance (2-tailed)
	mean	SD	*n*	mean	SD	*n*	mean	SD	*n*	
Light and sound ***Year 6***										
All pupils	3.06	1.12	102	3.24	1.06	50	2.88	1.15	52	*t(100)=1.622; p= 0.108*
Final cohort	2.90	1.07	71	3.10	1.06	31	2.76	1.07	40	*t(69)=1.344; p= 0.183*
Year 7										
Final cohort	3.04	1.22	67	3.18	1.09	28	2.95	1.32	39	*t(65)=0.756 p= 0.453*
Materials ***Year 5***										
All pupils	2.75	1.47	101	2.72	1.50	50	2.78	1.19	51	*t(99)=-0.218 p= 0.828*
Final cohort	2.69	1.47	71	2.50	1.46	30	2.83	1.48	41	*t(69)=-0.932 p= 0.355*
Year 6										
All pupils	2.68	1.31	99	2.67	1.36	48	2.69	1.27	51	*t(97)=-0.074 p= 0.941*
Final cohort	2.60	1.30	71	2.83	1.44	29	2.44	1.18	41	*t(68)=1.236 p= 0.221*
Year 7										
Final cohort	2.82	1.39	67	3.14	1.41	28	2.59	1.35	39	*t(65)=1.624 p= 0.109*

***** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

2(i). Mean attitude scores to biological science modules

Group	All pupils			Boys			Girls			Significance (2-tailed)
	mean	SD	*n*	mean	SD	*n*	mean	SD	*n*	
Year 5 **Living things**										
School OL pupils only	4.03	1.07	30	3.83	1.19	12	4.17	0.99	18	*t(28)=-0.834 p= 0.411*
Final cohort School OL pupils only	3.96	1.12	24	3.75	1.39	8	4.06	1.00	16	*t(22)=-0.635 p= 0.532* ***Mann Whitney Z=-0.420, p=0.697***
Human body										
School XL pupils only	3.71	1.14	45	3.72	1.10	25	3.70	1.22	20	*t(43)=0.058 p= 0.954*
Final cohort School XL pupils only	3.78	1.10	32	3.81	1.11	16	3.75	1.13	16	*t(30)=0.158 p= 0.875* ***Mann Whitney Z=-0.157, p=0.875***
Plants										
School XL pupils only	3.62	1.11	45	3.12	1.13	25	4.25	0.72	20	*t(43)=-3.886 p= 0.001***
Final cohort School XL Pupils only	3.84	0.92	32	3.25	0.86	16	4.44	0.51	16	*t(30)=-4.76 p= 0.001***
"Humplant" (mean of human body and plants)										
School XL Pupils only	3.67	0.85	45	3.42	0.77	25	3.98	0.85	20	*t(43)=-2.289 p= 0.027**
Final cohort School XL pupils only	3.81	0.69	32	3.53	0.59	16	4.09	0.69	16	*t(30)=-2.480 p= 0.019**

***** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

2(ii). Mean attitude scores to biological science modules

Group	All pupils			Boys			Girls			Significance (2-tailed)
	mean	SD	*n*	mean	SD	*n*	mean	SD	*n*	
Year 6 **Living things**										
All Year 6 pupils	3.54	1.30	102	3.32	1.22	50	3.75	1.36	52	$t(100)=-1.682$ $p=0.096$
Final cohort	3.46	1.33	71	3.23	1.19	30	3.63	1.41	41	$t(69)=-1.260$ $p=0.212$
Year 7 **Ecosystems**										
Final cohort	3.10	1.15	71	2.93	1.26	30	3.22	1.13	41	$t(69)=-1.038$ $p=0.303$
Processes of Life										
Final cohort	3.42	1.09	71	3.20	1.03	30	3.59	1.12	41	$t(69)=-1.483$ $p=0.143$

***** significant at the 0.05 level, $p<0.05$***
***** significant at the 0.01 level, $p<0.01$***
****** significant at the 0.001 level, $p<0.001$***

Some of the qualitative comments on individual science modules

1.Physical science modules
1.1 Electricity and magnetism

Out of the 25 Year 5 pupils at School UN who gave positive comments, 16 expanded their explanations to indicate that it was the constructive element ("making and fixing") in the practical sessions which led them to record positive scores. Some of the comments are given below:

Boys (13 comments[15])

UNW04 "I liket it because you **make it wake (work?)"**

UNW05 "we **made sercets"**

UNW11 "The **making of surkets"**

UNW22 **"Make** the **light blub work"**

Girls (12 comments[16])

UNW03 "we **made curcits"**

UNW06 "You got to do posters and **make a light work"**

UNW07 "you can learn how to **fix lights** etc"

UNW14 "Exelente I liked **making the serkit"**

In Year 6, several pupils commented favourably, on both the questionnaires and in the 'mini'-essays, about the practical aspects of "making circuits" and "(learning) to work with lights and batt(e)ries". Six pupils (1 boy, 5 girls) referred in their questionnaires to the practical issues of putting circuits or wires together:

Girl

UNW18 "It was good to try and **put the socets (circuits?) together"**

Boy

XLI13 **"We made lots of things light up"**

[15] Nine of which included references to 'making ' or 'fixing'
[16] Eight of which included references to 'making' or fixing'

1.2 Forces and Energy

In Year 5, as in the electricity module, the "making and doing" tasks were identified by 12 of the 25 pupils who made comments on their questionnaires:

Boys (13 comments[17])

UNW09	**"roling balls down diffrent serfices"**
UNW11	**"making the ball run down the bord"**
UNW22	"we **made paper aeroplanes"**
UNW26	"I like it because we **made paper airepane"**

Girls (9 comments[18])

UNW06	"liked **makeing the planes"**
UNW07	"you can **roll balls down a plank of wood"**
UNW10	**"making airoplanes"**
UNW17	**"doing planes"**

In Year 7, little detailed information was generally given about the reasons underlying the pupils' choices, other responses were spread through the whole range:

Boys

XLD17	"good fun"
XLD21	"O.K."
XLI09	"sad"

Girls

OLN11	"it was good because you did quite a lot of things"
OLU09	"O.K."
XLI21	"It was a bit boring"

[17] Seven of which referred to "making and doing" tasks
[18] Six of which referred to "making and doing" tasks

1.3 Space

In Year 5, 73 comments on the topic were provided by the Year 5 pupils (41 from boys, 32 from girls) of which only 9 (7 from boys, 2 from girls) demonstrated negative attitudes. A large number of the positive comments focussed on the opportunity for 'learning' or 'understanding'.

Boys[19]

XLD05	"it was fun to lener **(learn?)** it was fun and intesting and **I lerred** a lot"
XLD12	"It was intresting because **I learned a lot** from it"
XLI13	"**I like learning** about things I didnt know"
XLI19	"We **learnt a lot** about every planet. And **learnt** a ryme"

Girls[20]

XLD06	"**It tought me** what all the planets looked like"
XLI15	"It help me **to understand** space"
UNW21	"Because **I fond out** lost (lots) of good things about space"
UNW28	"we **learnt quite a lot** about the solar system"

Many of the positive attitudes recorded by the pupils were related to the opportunity to provide artwork and to utilise their drawing skills.

Boys

UNW04	"**I liket the donaning noit (drawing** on it?)"
UNW13	"We did **drawing**"
XLD19	"I enjoy talking about space & planets. **Good drawing** them"

Girls

UNW18	"it was allright I liked **drawing** the piche (picture)"
XLD08	"Interesting you can **draw** the planets"
XLI12	"Using the computer for **drawing** planets and stars"

[19] A total of seven responses included references to 'learning'
[20] Six comments included a reference to 'learning' or 'understanding'

In Year 7, both the boys' and girls' comments on this module were generally very positive and focussed mainly on the 'interest factor':

Boys	
OLI05	"This was really good and **interesting**"
XLD23	"Enjoyed, easy, **found out** lots of new things"
Girls	
OLN06	"it (is) good fun **we do fun things**"
OLN11	"it was quite **int(e)resting**"

1.4 Light and sound

Out of 57 written comments in Year 6, four referred in a positive way to 'experiments' or 'trying things out':

Boy	
XLI 13	"We done lots of **exsprenice** (experiments)"
Girls	
UNW12	"We done things and we got **to try things out**"
UNW18	"It was quite good because you could **expirment** things"
XLD09	"I like doing **experimenting**"

Six other pupils were fairly specific about what they had enjoyed:

Boys	
UNW09	"We used **prisms to bounce light**"
UNW22	"I liked making **light bounce**"
Girls	
UNW06	"We worked with **mirrors and wrote upside down**"
UNW10	"I liked doing the **mirrors and the prisms**"
UNW15	"I liked doing how **light reflects**"
UNW29	"You could see how **much reflections** there was"

In Year 7, at the positive end of the scale, the gender difference narrowed but the percentage of girls (39%) giving the module negative scores was more than twice that of the boys (18%). The comments from both sexes, however, reflected attitudes at both ends of the scale:

Boys

OLI12	"good fun"
XLI09	"boring"

Girls

OLU09	"brill"
OLN06	"It is really quite dull"

1.5 Materials

In Year 5, only 23 pupils (10 boys, 13 girls) out of the 97 respondents (51 boys, 46 girls) gave really positive comments; several of the respondents, mainly boys, focused on the experiments. Nine of the boys, and six of the girls, referred to experimental work in their responses.

Boys

UNW08	"I liked **making the smals (smells?)**"
UNW16	"Mixing powders **Fiss**"
UNW22	"**making bubles**"
XLI 13	"I liked the **exsperments**"

Girls

OLI 11	"It was great because we did **experiments**"
UNW28	"I liked it cos we did the fruit **experiment**"
XLD04	"the **experiment**"
XLD07	"I liked **doing experimenting** on materials"

1.6 Basic skills

In Year 7, a separate 'basic skills' module was introduced which involved a variety of practical experiences in weighing and measuring, together with an introduction to the use of several items of secondary school equipment. The main attraction for the boys seemed to be yet more opportunities to use a Bunsen burner in practical sessions:

Boys	
OLU06	"because I like using the Bunsen burner"
UNW29	"I like using Bunsen burners"
XLI03	"I liked using fire"
XLI9	"I like lighting fire"

Two boys and three girls thought the 'basic skills' was 'easy' and the lack of difficulty seemed to be the reason for awarding positive scores to this module.

Boys	
XLD23	"Nice,**easy** start"
OLN09	"quite **easy**"
Girls	
OLN05	"quite fun and **easy**"
OLN06	"because it's fun and **easy**"
XLI15	"nice **easy** start"

2. Biological science modules

2.1 Living things (School OL only)

Examination of the responses from the complete Year 5 pupils at School OL showed that there were positive comments on the topic from 10 boys and 14 girls. Six of the girls (but only two of the boys) recorded positive comments about this topic which related to either 'learning' or 'interest factor':

Boys	
OLI04	"It is fun **learning** about animals and food chains"
OLI06	"I find it quite **intresting** things about plants"
Girls	
OLI01	"It is good fun because the life cycles are **interesting**"
OLU10	"we **learnt** about animals and flowers"

There were comments from five pupils who specifically mentioned drawing or art work – four of these comments were very positive:

Boys	
OLU11	"Because **I like art** and we had to do lots"
Girls	
OLI11	"it was fun and **I like drawing**"
OLN02	"there is a lot of **drawing** to do and I like wildlife"
OLU12	"It is very very exciting. **I like drawing** living things"

2.2 'The human body' and 'plants' (School XL only)

At School XL, the only other primary school to cover biological science in Year 5, the subject matter was divided into two separate topics: **'The human body'** and **'plants'**.

In the human body topic there were positive references to the learning which had taken place:

Boys[21]	
XLD15	**"I learn more about myself** and my body; interesting, like practical work"
XLI 03	"Interesting. I loved that because I **found out how my body works"**
XLI19	"Saw a lot of X-rays and saw **how the body worked"**
Girls[22]	
XLD06	**"It taught me what my body looked like"**
XLD08	**"learning about whats inside you"**
XLI04	"it was alright because you can **lern how a body works"**

For the plants topic, 7 of the comments (from 4 girls and 3 boys) on the plants topic used the word "interesting" but reference to "planting" and "growing" appeared in 19 (of the 33) positive comments; these practical aspects were undoubtedly major contributors to the topic's popularity.

[21] There were nine responses in total which referred to 'learning' or 'finding out'
[22] Three responses (all shown above) referred to 'learning' or 'finding out'

Boys[23]

XLD17	"Interesting to see how they **grow**"
XLI09	"It was ok because we **palneted (planted)** Beans"
XLI13	"I like the **planting** but I didn't like drawing"
XLI16	"we got to **plant** some seeds"

Girls[24]

XLD03	"I like drawing, discussing, and **growing** them"
XLD09	"Interesting, **growing**, talking, writing"
XLI08	"We **planted** a plant and we can see it **grow**"
XLI22	"We got to **plant** some beens"

In Year 6, the majority of the 53 comments were positive and referred to the various aspects of human biology which had been of interest; plant biology attracted fewer positive comments.

[23] Ten responses referred to 'planting' or 'growing'
[24] Nine responses referred to 'planting' or 'growing'

1. Mean physical science and mean biological science scores: analysis by gender Year 5

Group	Gender	Physical science (adjusted)		Biological science		Difference between physical and biological science means *(paired samples t-test)*
		Mean	***SD***	***Mean***	***SD***	
Schools OL and XL *(n=75)*	Boys *(n=37)*	3.78	1.25	3.55	0.93	***t(36)= 0.989 p=0.329***
	Girls *(n=38)*	3.84	1.10	4.07	0.91	***t(37) = -1.011 p=0.319***
	All pupils *(n=75)*	3.81	1.17	3.81	0.95	*No difference between means*
	between genders	***t(73)=-0.214 p=0.831***		***t(73) = -2.405 p=0.019****		
Schools OL and XL **Cohort pupils only** *(n=56)*	Boys *(n=24)*	3.83	1.24	3.60	0.91	***t(22)= 0.982 p=0.337***
	Girls *(n=32)*	3.77	1.18	4.08	0.84	***t(30)= -1.128 p=0.268***
	All pupils *(n=56)*	3.80	1.19	3.85	0.89	***t(54)=-0.295 p=0.769***
	between genders	***t(53) = 0.181 p=0.857***		***t(54) = -2.013 p=0.049****		
Cohort pupils *(n=71)*	Boys *(n=30)*	3.63	1.22	*incomplete data (Schools OL and XL only)*		
	Girls *(n=41)*	3.72	1.26			
	All pupils *(n=71)*	3.68	1.23			
	between genders	***t(69) =- 0.509 p=0.613***				

**** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

2(i). Mean physical science and mean biological science scores: analysis by gender
Year 6

Group	Gender	Physical science (adjusted)		Biological science		Difference between physical and biological science means *(paired samples t-test)*
		Mean	*SD*	*Mean*	*SD*	
All pupils *(n=102)*	Boys *(n=50)*	3.39	0.85	3.32	1.22	*t(49) = 0.422 p=0.675*
	Girls *(n=52)*	3.00	1.02	3.75	1.36	*t(51) = -3.285 p=0.002***
	All pupils *(n=102)*	3.19	0.95	3.54	1.03	*t(101)=-2.366 p=0.020**
	between genders	*t(100) = 0.103 p=0.038**		*t(100)= -1.682 p=0.096*		
Cohort pupils *(n=71)*	Boys *(n=30)*	3.38	0.95	3.23	1.19	*t(29) = 0.884 p=0.384*
	Girls *(n=41)*	2.90	0.94	3.63	1.41	*t(40) = -2.857 p=0.007***
	All pupils *(n=71)*	3.11	0.97	3.46	1.33	*t(70)=-2.095 p=0.040**
	between genders	*t(69) = 2.121 p=0.038**		*t(69) = -1.260 p=0.212*		

** significant at the 0.05 level, p<0.05*
*** significant at the 0.01 level, p<0.01*
**** significant at the 0.001 level, p<0.001*

2 (ii) Mean physical science and mean biological science scores: analysis by gender Year 6 cont'd

Group	Gender	Physical science (adjusted)		Biological science		Difference between physical and biological science means *(paired samples t-test)*
		Mean	*SD*	*Mean*	*SD*	
Schools OL and XL *(n=75)*	Boys *(n=37)*	3.22	0.84	3.43	1.14	***t(36)= -1.434 p=0.160***
	Girls *(n=38)*	3.43	1.14	3.71	1.49	***t(37) = -3.400 p=0.002*****
	All pupils *(n=75)*	2.98	0.92	3.57	1.32	***t(74) = -3.575 p=0.001*****
	between genders	***t(73)=2.262 p=0.027****		***t(73) =- 0.906 p=0.368***		
Schools OL and XL Cohort pupils only *(n=56)*	Boys *(n=24)*	3.23	0.93	3.17	1.24	***t(23)= 0.365 p=0.718***
	Girls *(n=32)*	2.78	0.91	3.56	1.54	***t(31)= -2.492 p=0.018****
	All pupils *(n=56)*	2.97	0.94	3.39	1.42	***t(55)= -2.097 p=0.041***
	between genders	***t(54)=-1.808 p=0.076***		***t(54)=-1.031 p=0.307***		

**** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

3. Mean physical science and mean biological science scores: analysis by gender Years 7 and 8

Group	Gender	Physical science Mean	Physical science SD	Biological science Mean	Biological science SD	Difference between physical and biological science means *(paired samples t-test)*
Cohort *(n=71)*	***Year 7***					
	Boys *(n=30)*	3.51	0.76	3.06	1.00	***t(29)= -3.134 p=0.004*** **
	Girls *(n=41)*	3.03	0.88	3.40	0.97	***t(40)= 2.313 p=0.026****
	All pupils *(n=71)*	3.23	0.86	3.26	0.99	***t(70)= 0.191 p=0.849***
	between genders	***t(69)=2.384 p=0.020****		***t(69)=-1.396 p=0.167***		
	Year 8					
Cohort *(n=71)*	Boys *(n=30)*	4.07	0.84	2.80	1.10	***t(28) = -5.037 p=0.001***** **
	Girls *(n=41)*	2.95	0.93	3.29	1.19	***t(40) = 1.569 p=0.125***
	All pupils *(n=71)*	3.41	1.05	3.10	1.17	***t(69)= -1.677 p=0.098***
	between genders	***t(68)=5.157 p=0.001***** **		***t(69)=-1.783 p=0.079***		

**** significant at the 0.05 level, p<0.05***
***** significant at the 0.01 level, p<0.01***
****** significant at the 0.001 level, p<0.001***

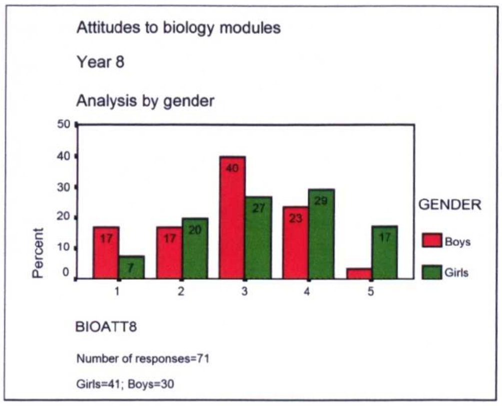
Comparison of mean attitude scores to physical and biological sciences: Years 5 - 8

Group	Higher mean scores					
	Physical sciences		Biological sciences		No difference	
	n	%	*n*	%	*n*	%
Year 5						
Pupils in Schools OL and XL *(n=75)*	14	18.7	28	62.6	14	18.7
Pupils in Schools OL and XL **Final cohort** *(n=56)*	9	16.1	37	66.1	10	17.8
Year 6						
All Year 6 *(n=102)*	28	27.4	63	61.8	11	10.8
Pupils in Schools OL and XL *(n=75)*	17	22.7	49	65.3	9	12.0
Pupils in Schools OL and XL **Final cohort** *(n=56)*	17	30.4	34	60.7	5	8.9
Final cohort *(n=71)*	20	28.2	45	63.3	6	8.5
Year 7						
Final cohort *(n=71)*	28	39.4	34	47.9	9	12.7
Year 8						
Final cohort *(n=71)*	38	54.4	23	32.9	9	12.7

Appendix 5.5

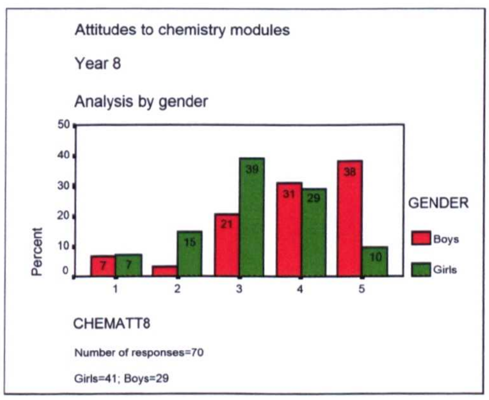
Distribution of attitude scores to biology, chemistry and physics modules: Year 8 Analysis by gender

Fig.5.32: Attitude scores to biology modules



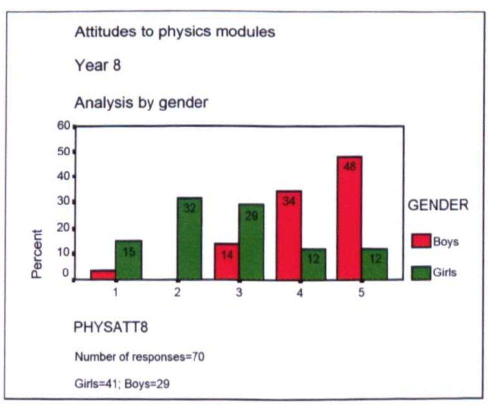
***Cohort mean** = 3.08, SD 1.17, n=71*
*(**Boys**: 2.80, SD 1.10, n=30; **Girls**: 3.29, SD 1.19, n=41)*

Fig.5.33: Attitude scores to chemistry modules



***Cohort mean** = 3.49, SD 1.15, n=70*
*(**Boys**: 3.90, SD 1.18, n=29; **Girls**: 3.20, SD 1.05, n=41)*

Fig.5.34: Attitude scores to physics modules



***Cohort mean**=3.37, SD 1.33, n=70*
*(**Boys**:4.24, SD 0.95, n=29;**Girls**: 2.76, SD 1.22, n=41)*

Mean attitude scores to biology, physics and chemistry modules: Year 8
Analysis by gender

Group	Gender	Biology modules		Chemistry modules		Physics modules		Gender difference
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Cohort	**Boys**	2.80 *(n=30)*	1.10	3.90 *(n=29)*	1.18	4.24 *(n=29)*	0.95	*Biology* *t(69) = -1.783, p=0.079*
	Girls	3.29 *(n=41)*	1.19	3.20 *(n=41)*	1.05	2.76 *(n=41)*	1.22	***Chemistry*** ***t(68)=2.615, p =0.011****
	All pupils	3.08 *(n=71)*	1.17	3.49 *(n=70)*	1.15	3.37 *(n=70)*	1.33	***Physics*** ***t(68)=5.479, p=0.001*****
Non-cohort	**Boys**	3.13 *(n=16)*	1.02	4.06 *(n=16)*	0.85	4.44 *(n=16)*	0.51	*Biology* *t(33)= -0.635, p=0.530*
	Girls	3.37 *(n=19)*	1.21	2.79 *(n=19)*	1.18	2.95 *(n=19)*	1.47	***Chemistry*** ***t(33)=3.587, p=0.001*****
	All pupils	3.26 *(n=35)*	1.12	3.37 *(n=35)*	1.21	3.63 *(n=35)*	1.35	***Physics*** ***t(33)=3.852, p=0.001*****

** significant at the 0.05 level, p<0.05*
*** significant at the 0.01 level, p<0.01*
**** significant at the 0.001 level, p<0.001*

Mean science scores: Years 5 to 8

Analysis by gender

Year	All pupils *(n=71)*		Boys *(n=30)*		Girls *(n=41)*		Difference between means[25]
	mean	SD	mean	SD	mean	SD	
5	3.79	0.84	3.68	0.82	3.88	0.76	*t(69)=-0.986 p=0.328*
6	3.23	0.86	3.32	0.94	3.16	0.79	*t(69)=0.772 p=0.443*
7	3.31	0.74	3.46	0.78	3.19	0.70	*t(69)=1.550 p=0.126*
8	3.28	0.83	3.59	0.78	3.06	0.81	*t(69)=2.733 p=0.008***

** ***significant at the 0.01 level, p<0.01***

[25] Independent samples *t*-test

Appendix 6.1

Correlations between "in-school" measures

	physav5a	physav6a	physave7	physave8	bioave5	bioave6	bioave7	bioave8
bioave5						0.280*		0.345**
invest5	0.268*							
sciavad5	0.651**				0.752**	0.262*		0.304**
sciav6ad		0.876**	0.443**	0.249*		0.614**		0.241*
physav6a			0.451**	0.397**				
bioave6			0.297*		0.280*			0.482**
Scifav6	0.241*							
Sciliks6		0.444**		0.268*		0.255*		0.268*
Sciint6								
Invest6		0.243*						
Humave6			0.260*					
Sciave7		0.339**	0.895**	0.342**		0.273*	0.649**	0.311**
Physave7		0.451**		0.415**		0.297*	0.382**	
Bioave7			0.382**					0.429**
Invest7		0.397**	0.554**			0.274*	0.298*	
Sciint7			0.306**				0.262*	
Sciquest7			0.455**	0.284*				
Scirel7			0.530**					
Sciperf7			0.509**	0.359**			0.238*	
Sciave8		0.299*	0.515**	0.777**			0.295*	0.511**
Inter78	-0.285*			0.371**				
invest8			0.364**	0.336**				
Help8	-0.284	0.258*	0.372**	0.301*				
Boring 8		-0.337**	-0.498**	-0.463**				
New8		0.309**	0.396**	0.389**				
Same8							-0.241*	
Write8		-0.235*					-0.259*	
Pract8							-0.274*	
Inter8		0.295*	0.329**	0.528**				
Sciperf8			0.405**	0.524**				
Scifav8				0.311**				
Sciscore8		0.327**	0.454**	0.786**			0.260*	0.364**
Bioatt8					0.345**	0.482**	0.429**	
Chematt8			0.360**	0.770**				
Physatt8		0.466**	0.380**	0.865**				
Physci8		0.397**	0.415**					
Invest9a		0.294*		0.256*				
KS3				0.391**				

** = significant at the 0.05 level, $p<0.05$*
*** = significant at the 0.01 level, $p<0.01$*
**** = significant at the 0.001 level, $p<0.001$*

Summary of pupils' comments on the perceived difficulty of science

Thirteen boys made comments – six boys thought it was 'about the same', four boys thought that it was 'easier' and one boy (OLU11) reported that he found 'it easier than some things, like maths and history'. Only two boys (XLI24 and UNW09) admitted to it being more difficult, the latter commenting that it was 'not as easy as maths'.

Twelve girls volunteered comments in their interviews (six of whom considered that the difficulty was 'about the same' as in other subjects). Five girls thought it was 'easier', 'probably easier' (XLI20) or 'sometimes easier' (UNW25); just one girl (UNW10) thought it was 'harder'. Few of the comments gave much insight as to *why* science was, or was not, perceived as difficult:

Girl
OLU12 "I found sciance (science) the **easiest** in my sats because they made it to **easy**" (score '5').
Boy
0LN03 "I find it quite **easy** because we do quite **easy** science"(score '4').

Both these pupils were regarded as 'higher ability' by their class teachers; the girl recorded a neutral score ('3') for her liking of science compared with other subjects and the boy recorded a strongly negative score ('1') in answer to the same question. Possibly the subject provided insufficient challenge for these pupils.

One boy (XLI18) found it "quite easy" because "my mum teaches me as well"; another boy (XLI06) who felt that science had been "very easy" explained that his father was a scientist and "he explains things to me". Only three pupils, all girls (OLU07, UNW19 and XLD09) related their lack of difficulty to their 'understanding' of science:

OLU07 "I find it easy because **I understand**"

UNW19 "because **I understand** most parts in science"

XLD09 "I always **understand** it"

The majority of the 13 pupils who qualified their neutral scores (score 3: "neither easy nor difficult") provided comments which justified their decisions:

Girl
UNW06 "**sometimes** it's hard work, **sometimes** it's not"

Boy
XLI16 "because (it's) **sometimes** easy, **sometimes** difficult"

In explaining one of the reasons behind his choice of a neutral score, one boy (OLU05) admitted:

OLU05 "some of it's hard because I don't lisson (listen) but it can be **easy sometimes**"

Another boy, XLD24, acknowledged the breadth of science by supporting his choice of the neutral score with the comment: "because it (science) fascinates me and bores me". In Year 7, five comments were made, all by girls, which were linked their perceived difficulty of the subject:

OLI02 "**quite hard**"(forces)

OLI03 "experiments- **quite complicated**" (light and sound)

OLN07 "I found it **hard** to understand" (ecosytems)

XLI15 "I found it **quite hard**" (ecosystems)

XLI20 "**quite hard**" (materials)

In Year 8, out of 159 miscellaneous comments on perceptions of difficulty, only 4 (2.5 %) were related to the understanding of the subject:

Girl
OLI03 "makes you feel thick"

Boys
OLN09 "we move onto the next stage too quickly"

UNW08 "hard to understand somethings"

XLD24 "things I can't understand"

Comparison of cohort and non-cohort data: Year 7

There were no significant differences between the cohort and non-cohort groups regarding the boys' and girls' mean attitude scores to investigations (see Table 6.2)

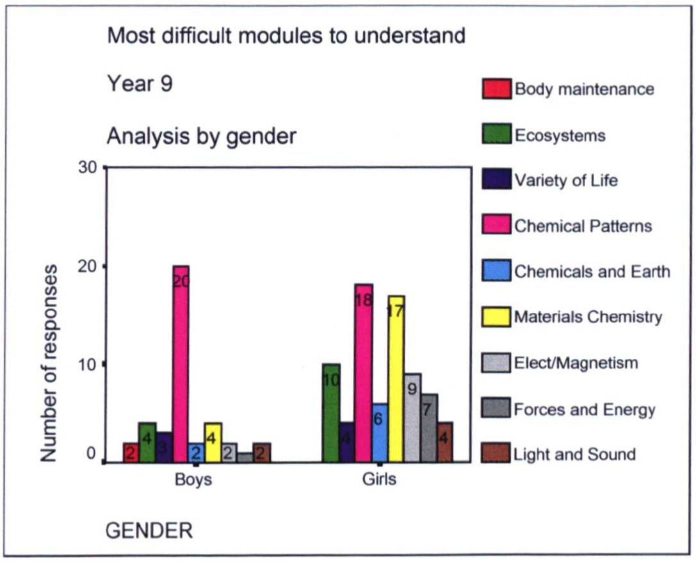
Table 6.2: Mean scores for attitudes to investigations: Year 7
Cohort and non-cohort pupils

Pupil group		Mean score	*SD*	*n*	Significance (2-tail)
Boys	Cohort	2.63	0.67	*30*	*(t=-0.617, df=58, p=0.539)*
	Non-cohort	2.73	0.58	*30*	
Girls	Cohort	2.46	0.55	*39*	*(t= -1.510, df=84, p=0.135)*
	Non-cohort	2.64	0.53	*47*	

Perceived difficulty of individual modules in Year 9 (extension to original study)

The pupils were asked (Appendix 4.5, Questions 1 and 2) to indicate which of the nine Year 9 modules they found most difficult to understand and, if possible, to try to explain their answers. Despite being asked to only name one module, several pupils gave multiple answers and so the data (Fig. 6.27) should be interpreted with caution.

Fig. 6.27: Most difficult modules to understand: Year 9



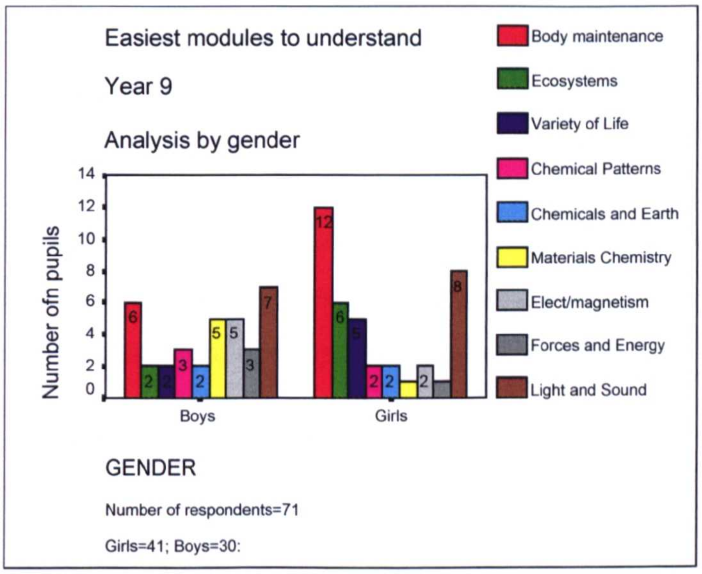
Allowing for some inconsistencies in reporting, it would appear that the majority of the boys found the Chemical Patterns modules most difficult. However, these responses may be based not so much on the difficulty of understanding but a lack of interest in the subject area which in turn led to a lack of attention in class. One pupil (UNW17) admitted: "it bors me so I don't listen." Whilst the girls, compared with the boys, generally reported more difficulty with the physics modules, the chemistry modules (particularly Chemical Patterns) appeared to cause some problems for both sexes. Although there were six comments (from 3 boys and 3 girls) which commented on the teacher's lack of explanation of the subject, the majority of the comments (both from boys and from girls) on the chemistry modules were that they were "complicated" (boys: OLI04, OLI05, OLN09, XLI19; girls: OLN05, UNW10) or "complicated and hard to remember" (XLD06, girl). A couple of the boys were concerned about the 'words':

XLD18 " the words were quite hard"

XLD19 "...there were too many chemical names"

The pupils were also asked (Appendix 4.5, Question 1(d)) to record the single module which they found easiest to understand but, again, multiple answers were given and so this cannot necessarily be taken as an accurate reflection of the pupils' views. However the girls' confidence with the biology modules (particularly Body Maintenance) is in line with the responses to the earlier question (Question 1(c)) on perceived difficulty (Fig.6.28).

Fig. 6.28: The easiest modules to understand: Year 9



An element of repetition of earlier work seemed to be beneficial for several pupils:

Boys

OLI04	"I know a lot about ecosystems already"
XLD18	"I learnt about it other places as well"

Girls

OLN05	"I already knew a lot about it"
UNW07	"I had done about it before and it is interesting"

Appendix 6.5

Pupils' comments on the 'interest factor' of science lessons

In Year 6, a few of the pupils' reported that their increased interest in the science topics was linked by the pupils to their improved understanding of the subject matter:

Girl

OLU12 "because I understand better"

Boy

OLI05 "It wasn't any harder because we were more clever than last year"

A couple of pupils, who thought that the science was more interesting, commented that there had been an extension of activities:

Girl

UNW19 "we've done more exsper(i)ments and investigations"

UNW29 "because there is more things to do"

Boy

XLD13 "because we have explored more things"

Despite these positive comments, a large number (22) of those pupils giving less positive scores ("about the same" and "less interesting") gave comments which emphasised the repetition, rather than the extension, of the previous year's science work:

Girl

OLI06 "there (they're) completely the same"

Boys

OLU06 "because it feels to me that we're doing the same thing as last year"

XLD1 "we do nearly the same thing"

XLI09 "because we have been doing the same things"

XLI19 "because we've done the same for two years"

Pupils' comments on their expectations of science lessons in their 'new' school tended to assume that 'science' meant the *physical* sciences and that the major difference would be the availability of "better" or "complicated" equipment:

Boys

OLI05 "Because there is better **equipment** so you can do more experiments and things like that"

OLU08 "because we'll be using **complicated equipment"**

Girls

OLU07 "Because you use **more equipment"**

UNW15 "they will be more int(e)resting because they have **more equi(p)ment"**

Several other pupils, mostly girls, linked the use of more, or better, equipment with an anticipation that their science lessons would be more 'interesting'

Girls

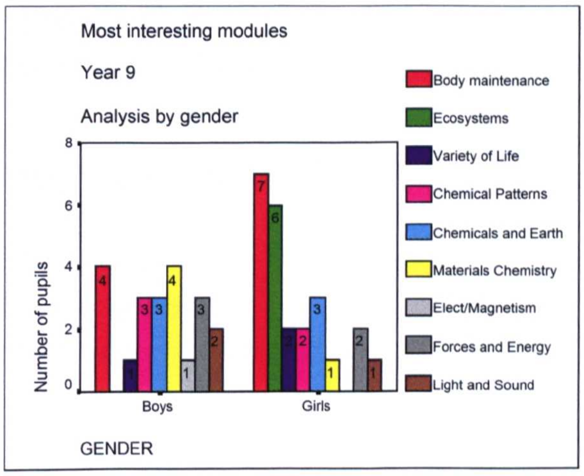
UNW25 "they have **more equ(ip)ment so more int(e)resting"**

OLI03 "More interesting, because of **more equipment"**

Interest in modules in Year 9 (extension to original study)

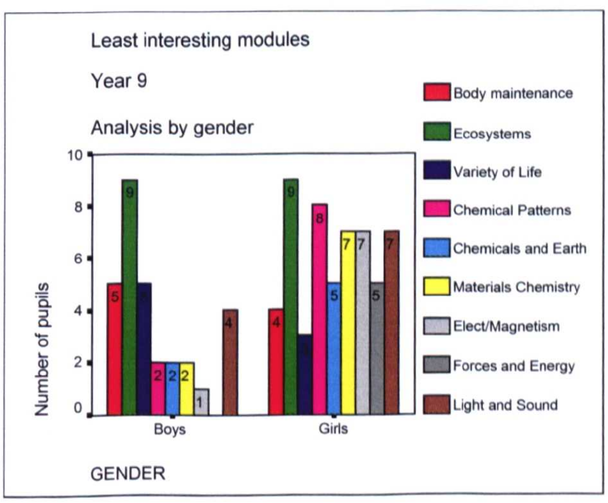
In Year 9 some questions were asked about attitudes to individual modules. The pupils were asked to record which one of the nine science modules they had studied that year was the most interesting and also which one was the least interesting (Appendix 4.5, Questions 1a and 1b). Several pupils gave multiple answers however and so the data analysis cannot necessarily be regarded as an accurate reflection of the pupils' views on this issue; where more than one module was named, the first cited module was recorded (Fig.6.29).

Fig. 6.29: Most interesting modules: Year 9



A request to the pupils to name the (one) module which they found the *least* interesting also received multiple answers from some of the pupils (Fig. 6.30).

Fig. 6.30: Least interesting modules: Year 9



Appendix 6.6

Examination of the qualitative comments (Appendix 4.5, Question 2) revealed some pointers as to what makes a module interesting:

Girls

OLI03	"I found it **easier to understand**"
OLN11	"it is **fun**"
UNW25	"I like it and **I can do it**"

Boys

OLI05	"We **learnt lots of new stuff**"
OLI12	"It was **more challenging**"
XLD22	"it was **all practical**"
XLD23	"it is **relevant** to everyday life"

In contrast, the *least* interesting modules attracted comments such as:

Girls

OLU07	"it was **hard**"
OLI11	"**it wasn't fun** to do"
OLI08	"it was **boring and difficult**"

Boys

OLN09	"it was what **we had done earlier**"
OLU11	"it was mostly **cutting and sticking**"
UNW09	"we **hardly did any practical work**"
XLI19	"**it's dull**"

Appendix 6.7

Pupils' comments on the quality of the pupil-teacher relationship

The annual questionnaires also allowed for pupils to comment at various points on any other issues which they felt might affect their feelings about science. The questionnaire in Year 7 (Appendix 4.4, Question 13) specifically sought comments about the pupils' relationships with their teachers.

Boys

UNW09	"I don't like the teacher because he never lisons to anything"
XLD12	"the teacher talks too long"
XLI09	"Mr.X. is very moody"

Girls

UNW10	"....don't like teacher"
UNW19	"I hate the teacher"
XLD05	"the teacher and the way he does it"

There was one positive comment about the teacher ("because the teacher is nice", XLI11, a girl) which was given as the main reason for the pupil regarding science as her favourite subject and eight positive comments about the teachers of other favourite subjects (English, Humanities and Performing Arts).

Girl

OLI03	"because I am good at it and I like the teacher"(English)

Boys

UNW13	"because we have a good teacher" (Humanities)
XLD16	"easy, best teacher" (Performing Arts)

Appendix 6.8

Pupils' comments on repetition of content

Of the 67 comments made by pupils about their interest in science during Year 6, sixteen pupils (4 girls, 12 boys) referred to repetition:

Boys	
OLU06	"because it feels to me that we're doing the same thing as last year"
XLI19	"because we've done the same for two years"
Girls	
XLD09	"because we were learning around about the same things"
XLI21	"because it was just revizing"

At the end of Year 7, comments made in response to the request to explain why science was not the pupil's favourite subject (Question 9, Appendix 4.3) lacked much detail beyond "it's boring", two cohort pupils did provide comments which referred to repetition:

XLI20 (girl)	"because we do things over and over again"
XLD19 (boy)	"because we do the same thing in Primary school"

Responses to Question 10 of the Year 7 questionnaire (concerning attitudes to individual modules) included:

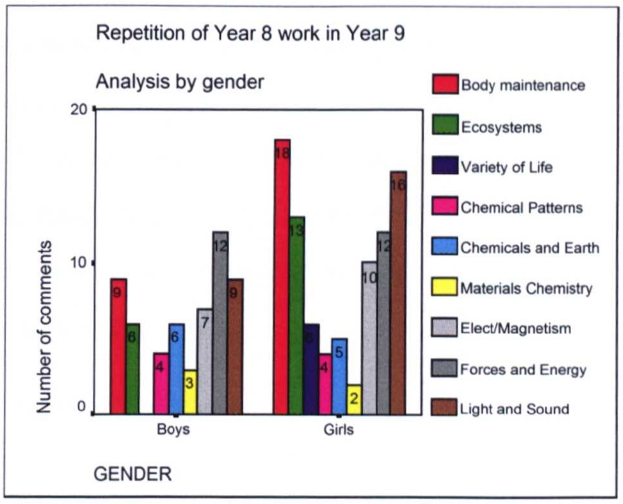
Girls	
OLN11	"It was the same as in primary school" (processes of life)
OLN07	"It felt like we were doing the same thing over again" (processes of life)
OLU12	"Borring I did it at (primary school)" (forces and energy)
Boys	
XLI18	"This was OK but I had done it before" (electricity and magnetism)
XLD21	"I have done it before" (space)

In Year 8, repetition attracted negative comments (Question 6) from two boys but five boys and six girls made positive comments about science:

Boy	
OLI05	"learning new things"
Girl	
OLI02	"you learn why things work"

The additional questionnaire issued in Year 9 asked the pupils (Appendix 4.5, Question 3(e)) to record which, if any, of the 9 modules covered a lot of the Year 8 work (Fig. 6.31).

Fig. 6.31: Year 9 pupils' perceptions of repetition of Year 8 work



Both the boys and the girls seemed to think that there was a lot of repetition in the physics modules although this may have been a lack of understanding that some new learning objectives had been added; this may also be the reason for the large number of girls reporting repetition in the Body Maintenance module.

Pupils' comments on writing and note-taking

In both Years 5 and 6 some pupils (particularly boys) had been critical of the amount of writing involved in science, particularly in topic areas where relatively little practical work was offered. By Year 7, as the primary school topics became more clearly differentiated into science and non-science modules, the main emphasis of the pupils' (particularly the boys') comments was of the imbalance between the 'writing' (too much) and the 'practical' (too little) components.

Boys

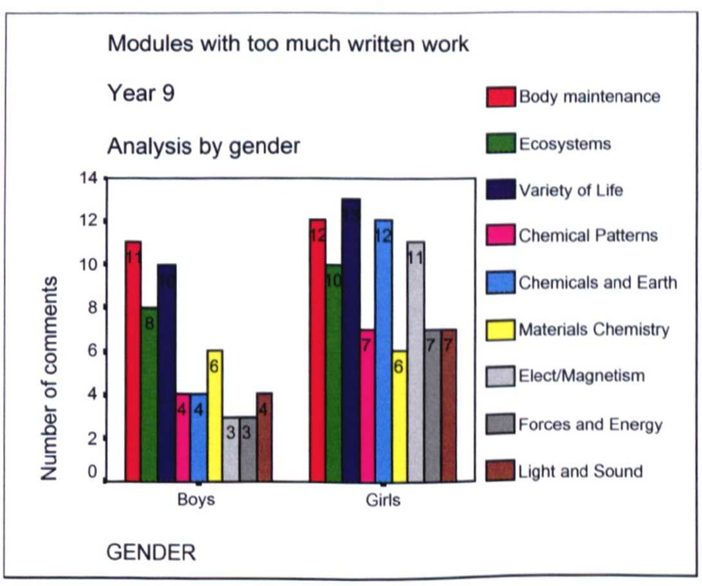
OLI04	"much writing not enough practicals"
OLU1	"I don't like the righting up part"
XLI18	"I dont like doing writing but I like pratical"

Girls

OLI03	"There are not enough 'hands on' experiments. Too much writing"
OLI08	"you write/copy from bo(a)rd more than experiments"
UNW15	"I don't like wrighting. I love doing experiments"

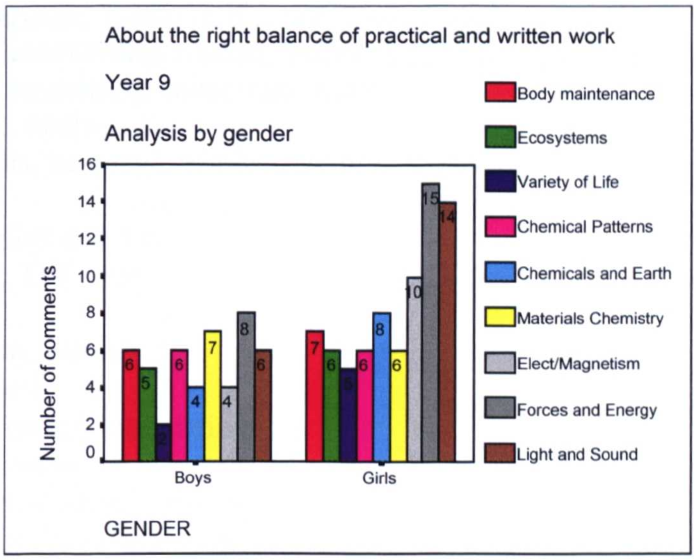
By Year 8, the data suggested that there was little change from the comments made, by both boys and girls, in Year 7 about writing and science; 18 boys and 20 girls included "too much writing" in their negative comments about science and copying from the board, or from books, was mentioned by 5 boys and 4 girls. The additional Year 9 questionnaire sought comments on whether the pupils thought that some of the modules had "too much written work" (Fig.6.32). This was included primarily to inform the schools' teaching strategies and lesson planning and was not an original research objective; multiple responses were permitted.

Fig.6.32: Modules with too much written work



Whilst the boys' comments appeared to reflect their negative views to the biology modules, the girls also considered that the biology modules involved "too much writing". The pupils were also asked, Question 3(h), to record which of the nine modules had, in their view, about the right balance of practical and written work; again multiple responses were permitted (Fig.6.33).

Fig. 6.33: Modules having about the right balance of practical and written work



When the request was presented in a more positive way, the girls' comments on the physics modules seem to be quite encouraging. Responses to both these requests, Questions 3(i) and 3(h), were reflected by the data from the complete Year 9 *(n=180)*.

Appendix 7.1

Favourite ('in-school') subjects, or activities: Year 5 (full year group)

Girls

OLI01	maths, PE (Ball games), Projects (at home),Art and Craft
OLI03	Drama, Maths, language, History, Art, Reading, R. E., Handwriting
OLN02	maths, art, filling things in, making things
OLN04	P.E. Dinnertime, Language, reading, dwaring
OLN05	Language, Topic, maths, Art, Tecnology
OLN06	pe, handwriting, reading, swimming, most topic, **science**, tecnogy
OLN07	P.E swimming, some topic work
OLN09	P.E., maths, arts
OLN11	maths, language, Topic, drawing, observation drawing
OLU10	English and Art
OLU12	P.E., D.T., Art
UNW03	maths, writing
UNW07	netball
UNW12	PE, maths ,art/drawing
UNW14	PE, maths, art
UNW15	sport, reeding, modling
UNW17	maths, language, **science**
UNW19	PE, maths, **science,** English
UNW21	lots of thing
UNW25	PE
XLD01	maths
XLD02	Writing, Maths, History, **Science**
XLD03	writing, drawing, rounders
XLD04	gardening club
XLD06	games-baseball, benchball, murder-death-blinck and Heads down
XLD07	history, writing
XLD08	nature, football
XLD09	history, art, topic books PE, outdoor games
XLD10	history, baseball
XLD11	baseball
XLI02	ganes, PE
XLI04	maths, **sience**, swiming
XLI07	PE(fun and I like to jump about)
XLI08	maths, PE and reading
XLI11	maths
XLI12	writing & sports
XLI15	math
XLI21	**Sience** and Mathes
XLI20	playing football looking at trees

Appendix 7.1

Favourite ('in-school') subjects, or activities: Year 5 (full year group)

Boys

OLI06	Drama, Singing, P.E ,.Art, Handwriting, language and R.E.
OLI09	Football
OLI12	"P.E. **science**"
OLN03	P.E., language and reading, swimming and orchestra
OLN08	"history, drawing, apparatus work"
OLN09	P.E, football, tennis, cricket, sprints
OLN10	History, football
OLU01	P.e., maths, writing
OLU03	P.E., art, history
OLU11	P.E., **sience** art
UNW04	PE
UNW08	maths
UNW09	maths
UNW11	PE, reading
UNW13	maths
UNW16	PE, **science**, language, art
UNW20	PE
UNW22	history, maths, PE, language
UNW24	maths, writen
UNW26	PE, Maths, **science**, English
UNW27	PE, storys, modled (modelling?) pictures
XLD05	maths
XLD12	Maths, Writing, History and Baseball
XLD13	baseball
XLD15	plants
XLD16	maths, writing, **sci**, geog., hist., bench ball, baseball, hockey, PE, Am.football
XLD17	baseball
XLD18	baseball, writing, hocky, reading
XLD19	maths, history, stall ball, baseball, bench ball
XLD20	marths
XLD21	maths
XLD22	baseball, football, Amanamen (American?) football

Appendix 7.1

Favourite ('in-school') subjects, or activities: Year 5 (full year group)

Boys (cont'd)

XLI01	(getting a good education all of them sometimes)
XLI03	English, maths, history, **sinece,** football, swimming, Am.football
XLI05	games, PE
XLI06	maths
XLI09	Wriging storys
XLI13	maths, **sience,** History
XLI14	football, cricket
XLI16	**Sience** and Maths
XLI17	mase(?)
XLI18	maths, wrighting, stories, pe, games
XLI19	Writing, **Science,** History, Geography, Mathes
XLI22	PE and games and sometimes reading
XLI23	My English i like best and art work

Mean attitude scores for Humanities topics: Years 5 and 6
Analysis by gender

Year 5				
Exploration				
Group	**Gender**	**Mean**	**SD**	**Significance**
Schools OL and UN Cohort pupils only *(n=38)*	Boys *(n=13)*	3.62	1.56	*t(36)=0.274, p=0.786 Mann Whitney Z=-0.492, p=0.623*
	Girls *(n=25)*	3.48	1.39	
The Tudors				
School XL Cohort pupils only *(n=32)*	Boys *(n=16)*	3.75	1.06	*t(30) =-1.005, p=0.323 Mann Whitney Z=-1.740, p=0.082*
	Girls *(n=16)*	4.19	1.38	
Villages and Towns				
School UN Cohort pupils only *(n=15)*	Boys *(n=6)*	2.83	1.17	*t(13) =1.334, p=0.205 Mann Whitney Z=-1.297, p=0.195*
	Girls *(n=9)*	2.11	0.93	
Mapwork				
Schools OL and XL Cohort pupils only *(n=56)*	Boys *(n=24)*	2.92	1.18	*t(54) =0.939, p=0.352 Mann Whitney Z=-0.952, p=0.341*
	Girls *(n=32)*	2.59	1.34	
Schools OL and XL All Year 5 pupils *(n=75)*	Boys *(n=37*	2.73	1.17	*t(73) =0.446, p=0.657 Mann Whitney Z=-0.525, p=0.600*
	Girls *(n=38)*	2.61	1.24	

Mean attitude scores for Humanities topics: Years 5 and 6
Analysis by gender

Year 6				
Different communities				
Group	**Gender**	**Mean**	**SD**	**Significance**
Cohort pupils only *(n=71)*	Boys *(n=30)*	4.10	0.92	*t(69)=0.224, p=0.824 Mann Whitney Z=0.179, p=0.858*
	Girls *(n=41)*	4.05	0.97	
All Year 6 pupils *(n=101)*	Boys *(n=49)*	4.00	1.08	*t(99) = 0.192, p=0.848 Mann Whitney Z=-0.519, p=0.603*
	Girls *(n=52)*	3.96	0.93	
Castles and houses				
School XL Cohort pupils only *(n=32)*	Boys *(n=16)*	4.06	1.24	*t(30) =0.138, p=0.891 Mann Whitney Z=0.061, p=0.951*
	Girls *(n=16)*	4.00	1.32	
School XL All Year 6 pupils *(n=45)*	Boys *(n=25)*	3.92	1.15	*t(43) =-0.084, p=0.933 Mann Whitney Z=-0.205, p=0.838*
	Girls *(n=20)*	3.95	1.23	

Mean attitude scores for Humanities topics: Years 5 and 6
Analysis by gender

Year 6				
The Tudors and the Greeks				
Group	**Gender**	**Mean**	**SD**	**Significance**
School UN Cohort pupils only *(n=15)*	Boys *(n=6)*	5.00	0.00	*(t cannot be computed)*
	Girls *(n=9)*	5.00	0.00	
School UN All Year 6 pupils *(n=27)*	Boys *(n=13)*	4.62	0.77	*t(25) =-1.437, p=0.163 Mann Whitney Z=-1.218, p=0.223*
	Girls *(n=14)*	4.93	0.27	
The Victorians				
School UN Cohort pupils only *(n=24)*	Boys *(n=8)*	3.88	1.55	*t(22) =-1.708, p=0.102 Mann Whitney Z=-1.138, p=0.255*
	Girls *(n=16)*	4.63	0.62	
School UN All Year 6 pupils *(n=30)*	Boys *(n=12)*	4.17	1.34	*t(28) =-1.401, p=0.172 Mann Whitney Z=-0.942, p=0.346*
	Girls *(n=18)*	4.67	0.59	

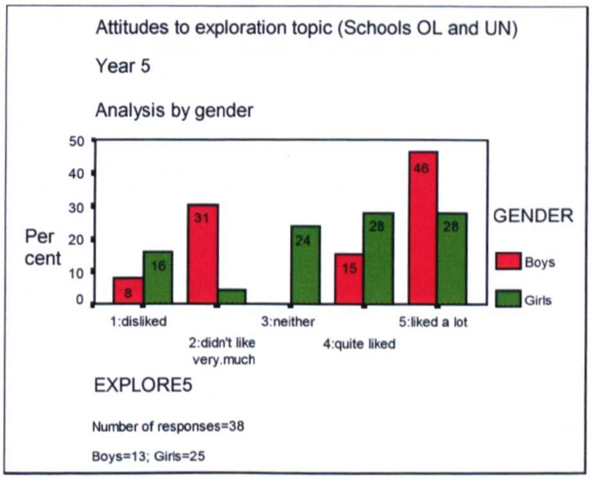
Analyses of pupils' comments on the humanities topics (Years 5 and 6)

(see Chapter 7.3)

Year 5: Exploration

The exploration topic received very positive responses. Although there was no significant difference between the gender means for this topic, the percentage of boys recording the highest score of '5' ('liked a lot') was particularly high (45%) - see Fig. 7.17.

Fig.7.17: Attitudes to 'Exploration' topic (Schools OL and UN)



The positive comments made by both boys and girls in OL and UN (particularly the latter) centred on the modelling work:

Boys

UNW03	"**Shei(l)ds and Aztec houses**"
UNW09	"**Made an Aztec house**"
UNW13	"We made **modles (models)**"

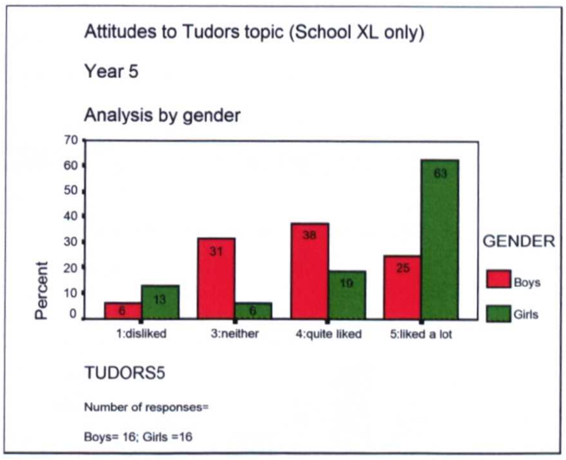
Girls

UNW14	"**building** house"
UNW19	"I liked **making Aztec houses**"
UNW06	"I liked **building things**"

Year 5: The Tudors

This was a popular module (see Fig. 7.18). It was, however, studied in only one school, (XL), and this explains the small sample size *(n=45)*.

Fig.7.18: Attitudes to 'The Tudors' topic (School XL)



The girls seemed to be particularly positive about this topic but they did not give much detail in their comments. Two girls favoured the Tudors topic because of the colouring and drawing but there was surprisingly little comment about the traditional girls' interests in the clothes, fashion or food of the day. The boys on the other hand gave much more specific comments about what fired their imaginations: executions, fire, plague, and battles.

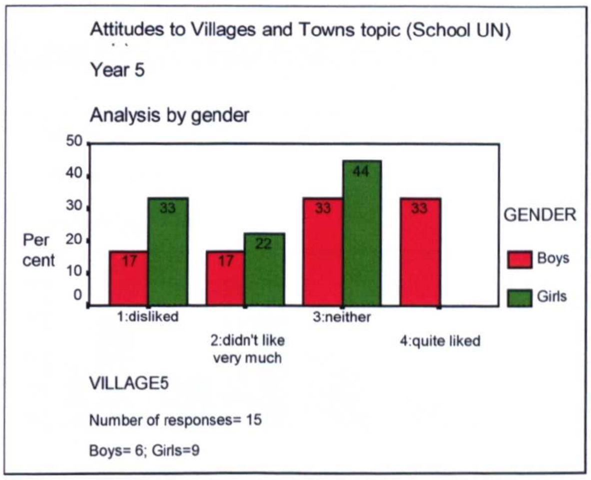
XLD16	"When people had there head cut off"
XLD19	"I like history and the great fire of London – plage (plague)
XLD24	"I like castls and wars and solders at battle"

Both boys and girls commented favourably on the inclusion, as part of the work on the topic, of a school trip (to Sulgrave Manor).

Year 5: Villages and Towns (School UN only)

This was not a particularly popular topic, especially with the girls (see Fig. 7.19). The mean scores of both the boys *(2.83)* and the girls *(2.11)* in this very small sub-group of the final cohort were lower than those awarded to either the 'Exploration' or 'The Tudors' topics (Fig.7.19).

Fig.7.19: Attitudes to 'Villages and Towns' topic (School UN)



The positive comments (taken from the whole year group) on the villages/towns module linked the higher scores with practical tasks such as drawing, or making models of, houses:

Girls

UNW19 "I liked it because we **drew** lots of houses"

UNW07 "you can **make models** and you can take (them) home"

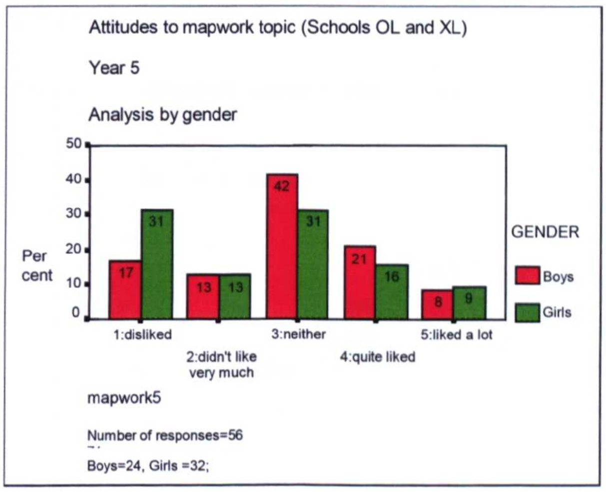
The negative comments, by both boys and girls, often cited too much writing as a reason for giving the topic a low score although several pupils commented that they disliked all the drawing: "all we did was drawing and colouring" (UNW09, a boy) and "it was boring because I did not like sti(c)king it toge(th)r" (UNW18, a girl).

Again it appeared that the positive attitudes to this humanities topic were stimulated by some interesting practical work; the writing, as in science lessons, seemed to be a negative point for both boys and girls.

Year 5: Mapwork

This topic was studied by pupils at Schools OL and XL only. For the cohort boys *(mean score: 2.92)* this was the least popular of the humanities topics (see Fig. 7.20). The cohort girls' *(n=32)* mean score of *2.59, SD 1.34*, was, however, very slightly higher than that of the very small group of girls *(n=9)* who studied the 'Villages and Towns' topic at School UN *(2.11, SD 0.93)*. The responses for the full year group *(n=75)* from these two schools (before attrition) were in very close agreement with those derived from the cohort pupils - see Appendix 7.2.

Fig.7.20: Attitudes to 'Mapwork' topic (Schools OL and XL)



The large number of pupils showing negative attitudes towards the mapwork topic rarely expanded their comments beyond "boring" or "boring not my sort of thing" (OLU09, a girl). Extreme views were held by two pupils: (OLI09, a boy) - "I hate cowardents (co-ordinates) and "It was very very boring" (XLI21, a girl). The degree of difficulty was occasionally cited : "Was hard for me to understand" (XLI23, boy). In a few cases, specific problems were highlighted:

Boys

XLD22	"it was hard for me because I can't read them"
XLI17	"because it was smol (small) print"

Girl

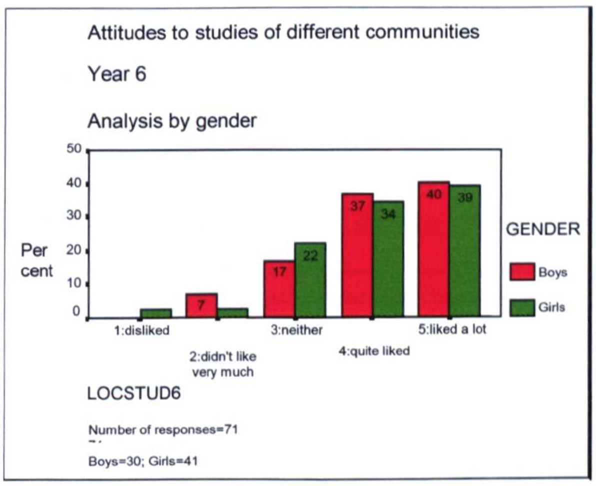
XLI08	"The pr(o)int was too small"

"We did lots of mapwork and finding places" (XLD23, boy, score 3), "It was quite fun finding places and drawing maps" (OLI04, boy).

Year 6: Studies of different communities

The cohort *(n=71)* mean score for this topic was *4.07, SD 0.95,* this was in good agreement with the mean attitude score *(3.98, SD 1.00)* of the complete Year 6 group *(n=101)* before attrition. Although there were differences between the schools in the choice of the location for the study, both boys and girls gave these topics very positive scores; 77% and 73% of the boys and the girls respectively recording a score of '4' ('quite liked') or '5' ('liked a lot') for this type of module (see Fig.7.21). There was no significant difference between the means in either the cohort, or the full year, group – see Appendix 7.2.

Fig. 7.21: Attitude to studies of different communities



The range of communities studied within this topic inevitably gave rise to a wide variety of comments. The very few negative comments (7 out of 61 responses) gave little explanation as to why the topic was regarded as "boring" but two pupils commented that they felt there was too much emphasis on reading and drawing.

Girl
UNW12 "We kept reading and it just carrid on and on"

Boy
UNW09 "there was a lot of drawing in it and Im not good at drawing so it took me a long time"

A large number of pupils commented that they had found the topics "interesting" or "fun" but, again, relatively few pupils expanded on the reasons for their interest. Not surprisingly, some of the attraction of the Isle of Wight study was because " you got to go for a five day trip" (boy, XLD16) and "we went on the beach a lot" (boy, XLI13).

Two girls, however, appreciated the fact that there were new things to learn:

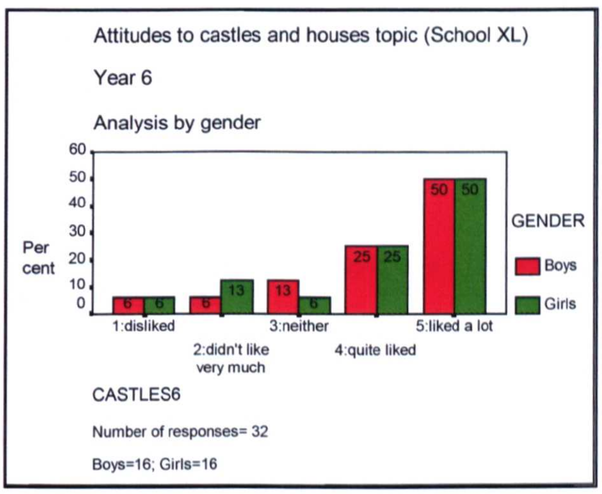
Girls	
OLN06	"I quite liked this topic because **I learnt** some names of countries I didn't know before".
OLN07	"I really enjoyed geography because **you learnt** how other people lived in other parts of the world".

The breadth of the 'historical' studies differed from school to school. 'Castles and houses' were studied by School XL, the Victorians and Ancient Greece by School OL and the Tudors and the Greeks by School UN.

Year 6: Castles and houses

These comments are derived from two classes within School XL. The cohort *(n=32)* mean attitude score was *4.03, SD 1.26*; there was no significant gender difference between the means (see Fig. 7.22).

Fig.7.22: Attitudes to 'castles and houses' topic (School XL)



This was clearly a popular topic. The comments predominantly referred to the 'interest' factor - two boys (XLI03 and XLI05) referring to the fact that they enjoyed "'finding out"' about things and two girls commenting that they liked "learning" about the past (XLD05) and about Queen Victoria in particular (XLD09). Two pupils gave the topic the highest score of '5' because "there's a lot of Art involved" (XLD16, a boy) and "because I liked doing the posters and the development" (XLI20, a girl). One boy (XLI13), however, was not so enthusiastic "we had to draw pitchers and I'm not very good at drawing".

Year 6: The Tudors and the Greeks

Only the pupils from School XL (*n=32*) studied the Tudors during Year 5. During Year 6, only the pupils at School UN covered both the Tudors and the ancient Greeks and the top '5' score was awarded to the topic by all 15 pupils. The data from the full Year 6 class (i.e. before attrition) at School UN showed that 93% of the girls and 77% of the boys awarded the history topics a score of '5'. The girls at School UN showed more enthusiasm for the history topics in Year 6 than the (Year 5) girls at School XL when only 63% of the girls had recorded scores at this level for the (single) topic on the Tudors.

Detailed comparisons of the pupils' attitudes to this topic with the Year 5 'history' module are inappropriate because of the very small numbers involved, the different schools and the split in emphasis (to include some studies of ancient Greece in School UN) in Year 6. There were, however, positive comments from 20 pupils several of whom commented that they enjoyed the practical aspects of making models of Tudor houses, the artwork or performing a play on a Tudor theme. Three pupils commented on their enjoyment of the 'learning' or 'research' aspects of the topic.

Girls

UNW12 "I liked it because you lurn about what happened on the earth before us"

UNW18 "We lernt a lot and it was good fun I liked doing research"

Boy

UNW19 "It was a really interesting topic and (it) taught me a lot of things about tuders"

The boys focussed more on the performing aspects:

Boys

UNW01 "We had to write a 'this is your life' and then we done a play"

UNW09 "I liked it because we did a play on it"

UNW02 "I like doing the picitres (pictures) and (we) did a play"

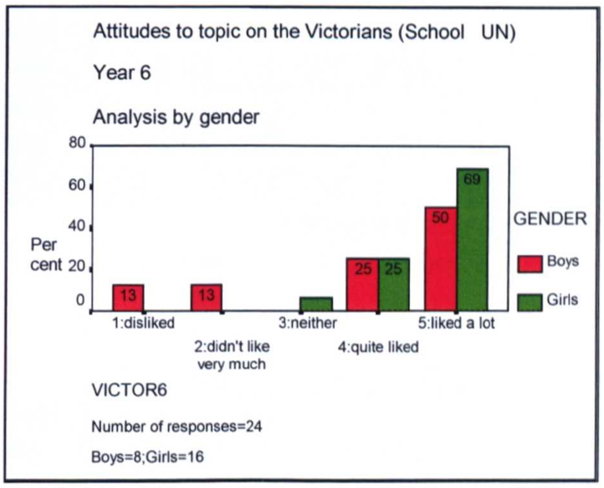
Girl

UNW28 "We made houses we did a play"

Year 6: The Victorians

This topic was only covered by the Year 6 class in School UN – see Fig. 7.23. The mean attitude scores for the cohort pupils and the complete Year 6 class were *4.37, SD 1.06* and *4.47, SD 0.97* respectively. This was a very small group *(n=24)* with twice as many girls as boys (Fig. 7.23).

Fig.7.23: Attitudes to 'Victorians' topic (School UN)



Although this was such an extremely popular module, few clues were given as to why it had been awarded such high scores by so many of the pupils. Five of the twelve pupils who provided written comments remarked that they found the module 'interesting' or 'very interesting'; three of the pupils made positive comments about the opportunity for 'learning' and one commented on the 'research' element:

Boys

OLI05	"I like **finding out** things, so it was good"
OLU08	"Enjoyed (it) its interesting and **informative"**

Girls

OLN07	"I really liked this because it was good learning about how people lived in the past. I liked **learning** about some of the childrens jobs and the adults".
OLU04	"The best topic even good **learning** about history"

None of the respondents mentioned the writing, artwork or modelling content of this module so it could be assumed that the style of presentation (through drama and re-enactment of a day in the life of a Victorian child) was sufficiently positive to provide a good stimulus for the children's engagement with the module.

Summary of highest mean attitude scores for science and humanities topics: Year 5

Mean score	All pupils *(n=71)*	Boys *(n=30)*	Girls *(n=41)*
	Physical science topics		
	Space 3.90	Space 3.97	Electricity and magnetism 3.89 Space 3.85
Mean physical sciences score	**3.24**	**3.18**	**3.28**
Mean physical sciences score (adjusted)[1]	**3.68**	**3.63**	**3.72**
	Biological science topics		
	Living things 3.96 (OL only)	Human body 3.81 (OL only)	Plants 4.44 (XL only)
Mean biological sciences score (Schools OL and XL only)	**3.88**	**3.60**	**4.07**
Mean science score (over all modules)	**3.47**	**3.34**	**3.57**
Mean science score (adjusted)[2]	**3.79**	**3.67**	**3.88**
	Humanities		
	The Tudors 3.84	The Tudors 3.75	Tudors 4.19
Mean humanities score (over all modules)	**3.19**	**3.28**	**3.12**

[1] excluding score for 'materials' topic (see Chapter 5.3)

Appendix 7.4

Summary of highest mean scores for science and humanities topics: Year 6

Mean score	All pupils	Boys	Girls
	Physical science topics		
	Electricity and Magnetism 3.31	Electricity and Magnetism 3.67	Electricity and Magnetism 3.05
Mean physical sciences score	**2.91**	**3.16**	**2.72**
Mean physical sciences score (as adjusted)[2]	**3.11**	**3.38**	**2.90**
	Biological science topics		
	Single topic in all schools: Living things		
Mean biological sciences score	**3.46**	**3.23**	**3.63**
Mean science score (over all modules)	**3.02**	**3.13**	**2.96**
Mean science score[3] (adjusted)	**3.23**	**3.32**	**3.16**
	Humanities		
	Tudors and Greeks (UN only) 5.00 Different communities 4.07	Tudors and Greeks (UN only) 5.00 Different communities 4.10	Tudors and Greeks (UN only) 5.00 Different communities 4.05
Mean humanities score (over all modules)	**4.20**	**4.12**	**4.26**

[2] excluding score for 'materials' topic (see Chapter 5.3)

Appendix 8.1

Year 5: Hobbies and interests outside school

Boys

OLI04	fishing; football; animals; cooking
OLI05	Piano; Animals; Scouts; Inters(play games)
OLI09	Football
OLI12	sport; science, history ,collecting rocks ,whaching TV, gardening, climbing trees
OLN09	colleting pogs, stikers, stamps, badges; running fast; "Cubs"
OLU03	football; cooking
OLU06	p.e; collecting 1p's, 5p's and 2p's
OLU11	stamp colecting; colecting coins; fishing; footbal; cooking
UNW01	football
UNW08	football, computer
UNW09	football, swimming, nature
UNW11	making things, paper things; mendingbikes
UNW13	football; cotting (collecting?) Beanos
UNW16	ride my bike; walk my bog; reabing; brawing
XLD12	football
XLD16	football; baseball; art
XLD17	nature; colecting stamps; fishing
XLD18	football
XLD19	collecting rubbers; tennis; snooker
XLD21	climming trees; swimming; cats; moter bikes
XLD22	riding my bike, going to the park
XLD23	athletics, football, reading, long distance running; badmiton
XLD24	drawing and making things
XLI03	collecting stickers; swimming; going to partys or discos
XLI09	having a friend round for tea
XLI14	football; cricket; pogs; football stickers
XLI17	moterBikers
XLI18	collecting badges and stamps, fruit stickers
XLI19	football; smimming; tennis; rugby
XLI23	Playing football with my mates

Girls

OLI01	Going to theam Parks... going camping with my cousin in the back garden
OLI02	Sport; Cooking; Reading
OLI03	Guides; Cooking; Collect. Music box mag; Dogs
OLI06	Drawing; Guides; Playing; collecting things
OLI08	Drowing; Swimming; Sports
OLI10	collecting stamps; rock climbing; P.E.
OLI11	Sport; swimming; cooking

Year 5: Hobbies and interests outside school

Girls (cont'd)

OLN04	gym: dwring (drawing?; reading: acting
OLN05	pogs; ice skating; tap dancing; P.E.; modern?; swimming; reading
OLN06	Cyclerly (cycling?) computer; swimming; pogs; owl (toys); making compotions round the streets
OLN07	ice skating; gymnasticks; Tennis; cooking; collect shells; making things
OLN11	Horseriding; gym, pig ("pog"?) collecting; swimming; reading
OLU04	brownies; cooking; swimming; bagminton playing the keyboard
OLU09	ballet; pogs, stamps, swimming
OLU12	ballet, bikeriding; Hunting; culeting(collecting?)pogs and old coins
UNW06	artwork, collecting stamps, coins; animals, wirte letters
UNW07	writing
UNW10	football, tennis, table tennis, cricket; Cubs
UNW15	reeding, swimming; stamp coulashoine (collection?),plaster molding
UNW17	swimming, netbal; football, tennis
UNW19	netball; collecting stamps; gymlastics; giydes
UNW25	football, baseball, basketball
XLD01	nayure; swimming; baseball
XLD02	Dancing; Singing
XLD03	drawing: writing stories
XLD04	dance
XLD05	nature;handstands; simmwing
XLD06	collecting thimbles, key-rings and rubers
XLD07	play in park; collect stickers
XLD09	horse riding; gymnastics
XLD11	football; keyring
XLI04	(collect)sikers (stickers) books and rubbers;swimming,roller blading
XLI08	football;pogs;swimming;playing
XLI11	games,collecting) stickers,rounders,cinema,town,shops
XLI12	Tennis;ronders,stallball;swmming
XLI15	going to swim at(swimimg center).And lear to do maths.
XLI20	football,tenis,swiming
XLI21	I like reading and sleeping

Year 6: Hobbies and interests outside school

Boys

OLI04	football, swimming, tennis and fishing and collecting gemstones
OLI05	tennis and photography
OLI09	bugs, colecting foot ball players(stickers?), football
OLU03	sport
OLU06	stories and my computer
OLU11	football, cricket, tennis, hockey
UNW01	football and spending lots of money
UNW08	football
UNW09	football, swimming, nature
UNW11	football and Liverpool
UNW13	football and playing computer
UNW16	football and playing with my frends
XLD12	seeing girls, Football, tennis and seeing my friends
XLD16	Football, biking, Hurdles and collecting figures
XLD17	Animals; collecting stamps and china animals; fishing
XLD18	football, cricket and playing with my brothers
XLD19	fishing
XLD21	Making and riding motor bikes
XLD22	moter racing and bike riding
XLD23	Redaing, Football and Swimming club
XLD24	drawing and ti KWON DO
XLI03	Tennis
XLI09	Katrate
XLI14	Football, playing on my computer
XLI17	Maise (mates ?)
XLI18	sticker colecting and tennis
XLI19	watching Grand Prix and playing football
XLI23	It is football

Appendix 8.2

Year 6: Hobbies and interests outside school

Girls

OLI01	reading horror books bikeriding, swimming
OLI02	karate
OLI03	Guides, tennis and history
OLI06	guides
OLI08	swimming
OLI10	collecting stamps
OLI11	swimming
OLN04	gymnastics singing and dancing
OLN05	Ice skating, skiing, swimming
OLN06	dancing, swimming, cycling
OLN07	swimming
OLN11	Horseriding, swimming and reading
OLU07	sport are my hobbies. I also like art and reading
OLU09	football and dancing
OLU12	Ballet and hunting
UNW03	collecting posters and listen to music
UNW06	netball, art, colleting stamps, postcards
UNW07	collecting foriegn stamps playing netball
UNW10	playing flute, bassoon, athletics
UNW15	stam colleting, net ball and Athaletics
UNW17	collection posters
UNW19	collecting stamps and postcards
UNW25	fishing
UNW29	football, cricket,,tennis and rugby
XLD01	swimming
XLD02	swimming,,bikeriding
XLD03	dont have hobbies ,Activite, Netball
XLD04	go running and taking dogs for a walk
XLD05	Drame Culb
XLD06	cars/netballs
XLD07	swimming and netball
XLD09	Horse riding
XLD11	riding and swimming
XLI04	Netball - Kung fu(?), Running
XLI08	mates
XLI11	Ice skating and Football
XLI12	swimming and dancing
XLI15	running and Bike riding
XLI20	swimming, rollerboting and netball

Year 5: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules[3]	Attitudes to investigations	Liking for science compared with other subjects
1. 'individual interest' participants (46)	3.63 *SD 0.71*	3.43 *SD 0.81*	2.40 *SD 0.66*	
non-participants (24)	3.17 *SD 0.71*	2.84 *SD 0.83*	2.24 *SD 0.77*	
ANOVA	*F(1,68)=6.661* *p=0.012**	*F(1,68)=8.139†* *p=0.006***	*F(1,62)=0.450* *p=0.505*	
Mann-Whitney	*Z=-2.272, p=0.023**	*Z=-2.029, p=0.043**	*Z=-0.549, p=0.583*	
2. 'performing arts' participants (8)	3.19 *SD 0.40*	2.87 *SD 0.58*	2.71 *SD 0.49*	
non-participants (63)	3.50 *SD 0.76*	3.28 *SD 0.88*	2.31 *SD 0.71*	
ANOVA	*F(1,69)=1.400* *p=0.241*	*F(1,69)=1.607* *p=0.209*	*F(1,63)=2.152* *p=0.147*	
Mann-Whitney	*Z=-1.515, p=0.130*	*Z=-0.397, p=0.691*	*Z=-1.444, p=0.149*	

p<0.05; ** p<0.01; *** p<0.001   ***† outlier removed***

[3] As adjusted ('material' score deleted)

Appendix 8.3

Year 5: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	**Mean attitude to science score (all modules)**	**Mean attitude score to physical science modules[4]**	**Attitudes to investigations**	**Liking for science compared with other subjects**
3. 'sport' participants (47)	3.41 *SD 0.74*	3.72 *SD 1.18*	2.30 *SD 0.71*	
non-participants (23)	3.60 *SD 0.72*	3.62 *SD 1.36*	2.45 *SD 0.67*	
ANOVA	*F(1,69)=1.02 p=0.316*	*F(1,68)=0.088 p=0.768*	*F(1,63)=0.696 p=0.407*	
Mann-Whitney	*Z=-1.277, p=0.202*	*Z=-0.147, p=0.883*	*Z=-0.839, p=0.401*	
4. 'other outdoor' participants (17)	3.77 *SD 0.55*	3.51 *SD 0.71*	2.40 *SD 0.51*	
non-participants (53)	3.41 *SD 0.74*	3.19 *SD 0.84*	2.37 *SD 0.73*	
ANOVA	*F(1,68)=3.355 p=0.071*	*F(1,68)=2.060† p=0.156*	*F(1,62)=0.026 p=0.872*	
Mann-Whitney	*Z=-1.652, p=0.099*	*Z=-1.019, p=0.308*	*Z=-0.503, p=0.615*	
5.'group activities: non-sport'	*Only 6 participants*			

p<0.05; ** p<0.01; *** p<0.001 ***† outlier removed***

[4] As adjusted ('material' score deleted)

Year 6: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules[5]	Attitudes to investigations	Liking for science compared with other subjects
1.'individual interest' participants (24)	3.16 *SD 0.83*	3.38 *SD 0.88*	2.38 *SD 0.65*	2.96 *SD 0.86*
non-participants (47)	2.96 *SD 0.88*	2.97 *SD 0.99*	2.16 *SD 0.67*	3.39 *SD 1.18*
ANOVA	*F(1,69)=0.797 p=0.375*	*F(1,69)=2.889 p=0.094*	*F(1,66)=1.619 p=0.208*	*F(1,68)=2.516 p=0.117*
Mann-Whitney	*Z=-0.702, p=0.482*	*Z=-1.865, p=0.062*	*Z=-1.308, p=0.191*	*Z=-1.762, p=0.078*
2.'performing arts' participants (8)	2.91 *SD 0.811*	2.44 *SD 0.68*	1.75 *SD 0.71*	3.25 *SD 1.16*
non-participants (63)	3.04 *SD 0.87*	3.19 *SD 0.97*	2.30 *SD 0.64*	3.24 *SD 1.10*
ANOVA	*F(1,69)=0.178 p=0.694*	*F(1,69)=4.520 p=0.037**	*F(1,63)=4.995 p=0.029**	*F(1,68)=0.000 p=0.985*
Mann-Whitney	*Z=-0.576, p=0.565*	*Z=-2.325, p=0.020**	*Z= -0.070, p=0.038**	*Z=-0.010, p=0.992*

p<0.05; ** p<0.01; *** p<0.001 ***† outlier removed***

[5] As adjusted ('material' score deleted)

Year 6: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules[6]	Attitudes to investigations	Liking for science compared with other subjects
3. 'sport' participants (50)	3.03 *SD 0.84*	3.15 *SD 0.96*	2.20 *SD 0.70*	3.39 *SD 1.00*
non-participants (19)	3.04 *SD 0.94*	3.00 *SD 1.00*	2.32 *SD 0.58*	3.00 *SD 1.21*
ANOVA	*F(1,69)=0.002 p=0.962*	*F(1,69)=0.353 p=0.555*	*F(1,67)=0.411 p=0.524*	*F(1,67)=1.892 p=0.174*
Mann-Whitney	*Z=-0.114, p=0.909*	*Z=-0.322, p=0.747*	*Z=-0.534, p=0.593*	*Z=-1.063,p=0.288*
4. 'other outdoor' participants (57)	2.96 *SD 0.56*	2.96 *SD 0.63*	2.21 *SD 0.58*	3.50 *SD 1.02*
non-participants (14)	3.04 *SD 0.92*	3.14 *SD 1.03*	2.24 *SD 0.69*	3.18 *SD 1.11*
ANOVA	*F(1,69)=0.094 p=0.760*	*F(1,69)=0.369 p=0.545*	*F(1,67)=0.012 p=0.913*	*F(1,68)=0.963 p=0.330*
Mann-Whitney	*Z=-0.327, p=0.744*	*Z=-0.828, p=0.408*	*Z=-0.231, p=0.818*	*Z=-0.973,p=0.331*
5.'group activities: non-sport'	*Only two participants*			

p<0.05; **p<0.01; ***p<0.001   ***† outlier removed***

[6] As adjusted ('material' score deleted)

Appendix 8.3

Year 7: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules	Attitudes to investigations	Interest in science compared with previous year
1.'individual interest' participants (9)	3.80 *SD 0.31*	3.63 *SD 0.88*	2.63 *SD 0.74*	2.78 *SD 0.67*
non-participants (62)	3.23 *SD 0.76*	3.18 *SD 0.89*	2.53 *SD 0.60*	2.63 *SD 0.64*
ANOVA	*F(1,68)=4.683†* *p=0.034**	*F(1,68)=2.119* *p=0.150*	*F(1,66)=0.158†* *p=0.692*	*F(1,67)=0.398†* *p=0.530*
Mann-Whitney	*Z=-2.510, p=0.012**	*Z=-1.621, p=0.105*	*Z=-0.715, p=0.475*	*Z=-1.002, p=0.316*
2.'performing arts' participants (9)	3.52 *SD 0.44*	3.58 *SD 0.60*	2.56 *SD 0.73*	2.44 *SD 0.88*
non-participants (62)	3.28 *SD 0.78*	3.20 *SD 0.89*	2.54 *SD 0.60*	2.66 *SD 0.63*
ANOVA	*F(1,68)=0.848* *p=0.360*	*F(1,68)=1.542* *p=0.219*	*F(1,66)=0.004* *p=0.952*	*F(1,68)=0.794* *p=0.376*
Mann-Whitney	*Z=-0.874, p=0.382*	*Z=-1.205, p=0.228*	*Z=-0.299, p=0.765*	*Z=-0.630, p=0.528*

p<0.05; **p<0.01; ***p<0.001   ***† outlier removed***

Year 7: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules	Attitudes to investigations	Liking for science compared with other subjects
3. 'sport' participants (58)	3.29 *SD 0.71*	3.22 *SD 0.86*	2.53 *SD 0.63*	2.61 *SD 0.68*
non-participants (13)	3.36 *SD 0.88*	3.29 *SD 0.89*	2.58 *SD 0.51*	2.85 *SD 0.38*
ANOVA	*F(1,69)=0.101 p=0.751*	*F(1,69)=0.055 p=0.816*	*F(1,67)=0.086 p=0.770*	*F(1,67)=1.493† p=0.226*
Mann-Whitney	*Z=-0.596, p=0.551*	*Z=-0.455, p=0.649*	*Z=-0.101, p=0.920*	*Z=-1.172, p=0.241*
4.'other outdoor activities' participants (11)	3.29 *SD 0.71*	3.28 *SD 0.80*	2.80 *SD 0.42*	2.64 *SD 0.50*
non-participants (59)	3.36 *SD 0.88*	3.26 *SD 0.85*	2.50 *SD 0.63*	2.66 *SD 0.66*
ANOVA	*F(1,69)=0.101 p=0.751*	*F(1,68)=0.009 p=0.926†*	*F(1,66)=2.102 p=0.152†*	*F(1,67)=0.008 p=0.929†*
Mann-Whitney	*Z=-0.454, p=0.650*	*Z=-0.351, p=0.726*	*Z=-1.478, p=0.139*	*Z=-0.445, p=0.656*
5. 'group activities:non-sport'	*Only 4 participants*			

$^*p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$ **† *outlier removed***

Appendix 8.3

Year 8: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules	Attitudes to investigations	Interest in Science
1. 'individual interest' participants (17)	3.09 *SD 0.93*	3.24 *SD 1.13*	2.59 *SD 0.62*	3.18 *SD 1.24*
non-participants (54)	3.34 *SD 0.80*	3.47 *SD 1.02*	2.79 *SD 0.41*	3.33 *SD 1.12*
ANOVA	*F(1,69)=1.149 p=0.288*	*F(1,68)=654 p=0.421*	*F(1,68)=2.461 p=0.121*	*F(1,69)=0.243 p=0.624*
Mann-Whitney	*Z=-0.496, p=0.620*	*Z=-0.718, p=0.473*	*Z=-0.842, p=0.400*	*Z=-0.523, p=0.601*
2.'performing arts' participants (13)	3.41 *SD 0.93*	3.19 *SD 1.32*	2.85 *SD 0.38*	3.46 *SD 1.20*
non-participants (58)	3.64 *SD 0.82*	3.46 *SD 0.98*	2.73 *SD 0.49*	3.26 *SD 1.13*
ANOVA	*F(1,69)=0.345 p=0.559*	*F(1,68)=0.716 p=0.400*	*F(1,67)=0.626 p=0.432†*	*F(1,69)=0.334 p=0.565*
Mann-Whitney	*Z=-0.496, p=0.620*	*Z=-0.718, p=0.473*	*Z=-0.842, p=0.400*	*Z=-0.656, p=0.512*

p<0.05; **p<0.01; ***p<0.001 ***† outlier removed***

Year 8: Involvement in "Out-of-school" activities and attitudes to science scores

Category of Activities	Mean attitude to science score (all modules)	Mean attitude score to physical science modules	Attitudes to investigations	Interest in Science
3. 'sport' participants (58)	3.37 *SD 0.71*	3.50 *SD 0.98*	2.79 *SD 0.41*	3.45 *SD 1.05*
non-participants (12)	2.83 *SD 1.22*	2.91 *SD 1.30*	2.55 *SD 0.69*	2.50 *SD 1.31*
ANOVA	*F(1,69)=4.467 p=0.038**	*F(1,68)=3.139 p=0.081*	*F(1,67)=2.667† p=0.107*	*F(1,68)=7.474 p=0.008***
Mann-Whitney	*Z=-1.457, p=0.145*	*Z=-1.535, p=0.125*	*Z=-1.149, p=0.251*	*Z=-2.496, p=0.013**
4.'other outdoor activities' participants (18)	29 *SD 0.89*	3.42 *SD 1.00*	2.83 *SD 0.38*	3.44 *SD 1.10*
non-participants (53)	3.32 *SD 0.77*	3.41 *SD 1.07*	2.73 *SD 0.49*	3.23 *SD 1.17*
ANOVA	*F(1,68)=0.019 p=0.891†*	*F(1,68)=0.000 p=0.991*	*F(1,67)=0.707 p=0.403†*	*F(1,68)=0.463 p=0.499†*
Mann-Whitney	*Z=-0.280, p=0.779*	*Z=-0.014, p=0.989*	*Z=-0.894, p=0.372*	*Z=-0.766, p=0.444*
5.'group activities: non-sport'	*Only one participant*			

p<0.05; ** p<0.01; *** p<0.001**   ***† outlier removed

Year 7: Hobbies and interests outside school:

Boys

OLI04	fishing, football, scouts
OLI05	tennis, oboe playing, piano, table tennis
OLI09	football
OLI12	streethockey, Scouts, rugby, cricket, tennis sailing, swimming
OLN09	riding my bike
OLU03	football, cricket
OLU06	tennis, swimming, writing stories
OLU11	football and motor bike racing
UNW01	tennis
UNW08	football, fishing, riding BMX
UNW09	swimming, football, karate, cricket
UNW11	football, tennis
UNW13	rollerblading, biking riding, fishing
UNW16	rugby
XLD12	football, tennis, swimming, girls
XLD16	football, tennis, cricket
XLD17	fishing, football
XLD18	cricket, tennis, football
XLD19	fishing, football
XLD21	street hockey
XLD22	rugby, swimming
XLD23	swimming, football, badminton
XLD24	collecting ??? warriors, model making
XLI03	playing on my computer, football, swimming
XLI09	karate, streethockey
XLI14	football, tennis, cricket
XLI17	Baspoll (basketball?)
XLI18	collect bages and diecastmodle cars and i like riding my bike
XLI19	football, tennis
XLI23	tennis, football

Year 7: Hobbies and interests outside school

Girls

OLI01	cricket, rollerblading
OLI02	karate, running, shopping, eating
OLI03	swimming, shopping, running, discos, rollerblading
OLI06	swimming, biking, shopping
OLI08	swimming, running club, shopping, rollerblading, youth club
OLI10	collecting stamps, rollerblading, badminton, football, cycling
OLN04	dance, gym., swimming, roler blading, jogging
OLN05	ice skating, swimming, roller blading
OLN06	swimming, rollerbladeing, netball
OLN07	dancing, swimming, shopping
OLN11	swimming, clothes shopping, cooking
OLU07	gymnastics, football, athletics
OLU09	football, dance,sailing, collecting things
OLU12	ballet, dance, building things
UNW03	listening to music going out with my friends
UNW06	seeing friends, netball, football, art, shopping, eating, talkin
UNW07	cross stich, swimming, roller blading
UNW10	flute playing, tennis, swimming
UNW15	dancing, running, hockey
UNW17	swimming, horse riding, dancing
UNW19	gym., football
UNW25	football, Guides
UNW29	P.E., football, tennis, rugby
XLD01	traperlining
XLD02	sailing,running,shopping,discos,Guides
XLD03	youth club (The Forum)
XLD04	swiming and jogging
XLD05	tramperling, sorrie(?), Athertaies (athletics?)
XLD06	going to Silverstone
XLD09	horse riding, ice skating, boys and football
XLD11	football, athletics
XLI04	swimming, gym, trampoling
XLI08	youth club (Forum)
XLI11	horse riding, swiming
XLI15	football
XLI20	swimming, tennis, running,football
XLI21	swimming

Appendix 8.5

Year 8: Hobbies and interests outside school

Boys

OLI04	fishing, football, tennis, table tennis, cricket, swimming
OLI05	computer. Tennis, Pool, Snooker
OLI09	football, tenis
OLI12	skating, roller hockey, football, rugby, cricket, tennis, badminton, pool, snooker
OLN09	swimming , cycling , roller blading
OLU03	football, cricket, rugby, athletic, dance
OLU06	swimming, riding bikes and playing on my computer
OLU11	motorcross, cars mechanical work and desighn and fishing
UNW01	playing football...
UNW08	football, athletics, watching TV. Playing on my N64(?)
UNW09	football, cricket, tennis, rugby, karate, swimming, violin
UNW11	football, tennis, badminton
UNW13	basketball
UNW16	motor cross and basketball
XLD12	basketball, football and TV
XLD16	football , tennis, private gym (Birmingham), cricket, running, athletics
XLD17	fishing, football and swimming
XLD18	football, tennis and going fishing
XLD21	...skating , street hockey (anything to do with sports)
XLD22	rugby, bike riding, remote control cars, motor bikes
XLD23	swimming, football. badminton
XLD24	playing on playstation, completing games and making records
XLI03	tennis, pool, snooker
XLI09	street hockey, karate, go karting and football
XLI14	football, cricket, squash, tennis, fishing, swimming
XLI17	I like to ride my BMX bike
XLI18	tennis, model car collecting, watching videos
XLI19	I like playing football, tennis and snooker/pool
XLI23	fishing, tennis, football, clay pigeon shooting, swimming, street hockey, baseball, basketball

Year 8: Hobbies and interests outside school

XLI23	fishing, tennis,football, clay pigeon shooting, swimming, street hockey, baseball, basketball
OLI01	hanging out with my friends.........(list), collecting CD's
OLI02	karate, writing, reading, drawing, playing with mates
OLI03	swimming, cycling, shopping
OLI06	meeting with my friends, swimming
OLI08	mainly sports e.g. swimming, running. Shopping
OLI10	stamp collecting, shopping for clothes, badminton and tennis
OLI11	swimming, netball
OLN04	gym club, flute playing, dance, swimming
OLN05	ice skating and dancing
OLN06	outside schol I go to gymantics and my hobbies are swimming
OLN07	Dancing. I also enjoy bike riding, walking and going out with my friends
OLN11	swimming, watching TV, cooking
OLU04	sailing, messing around with friends
OLU07	sport, TV, music
OLU09	sailing, going up the park, watching TV
OLU12	sailing, fishing, shooting, art and weightlifting
UNW03	music (listening to), football
UNW06	bowling, cycling, art, being with friends, sport
UNW07	playing, watching TV doing things with mates, pop groups, boys!
UNW10	playing flute, trampolining
UNW15	dance, acting, running, hockey
UNW17	trampolining, swimming and horseriding
UNW19	sport
UNW25	sailing, football, rounders, bike riding
UNW29	football, tennis, rugby, going out with friends and computer
XLD01	swimming
XLD02	singing, dancing
XLD05	acting in school proction (production?)
XLD06	going out with my friends, swimming, animals, watching football
XLD09	partying (joke) horse riding and chilling with my mates
XLD11	football, swimming
XLI04	swiming
XLI08	sport
XLI11	swimming, fotball, music
XLI15	guides, football
XLI20	swimming, bike riding, walking
XLI21	animal welfare and biking

Pupils' views on transfer to the comprehensive school

Pupils were asked at the beginning of the Year 7 questionnaire (Appendix 4.3, Question 2) to identify in what way, or ways, the comprehensive was the same, or different, compared with what they had expected when they were in Year 6. The responses to the question from both groups fell into one or more of four sub-categories of expectations:

1) The content, or anticipated difficulty of the **lessons** or **homework** and the **teachers or teaching style;**

2) The concern about noise and the size of the **site** together with possible problems associated with movement around the site;

3) The differences in the **school day** and the opportunities for **sport/clubs**

and 4) fear of **bullying or other personal problems**

For the vast majority of pupils the expectations on transfer seemed to have been realised:

Girl
XLD04 "It was what I expected because I had family here"

Boy
UNW08 "It was just as I expected"

A girl (SN11), who came from another area outside the locality, simply commented: "It was different as I expected". The vast majority of the pupils' had very positive attitudes towards their new school:

Girls
OLI03 "I can't wait to go to (school)"

UNW14 "I am looking forward to the change and to make new friends"

XLI04 "Nothing worries me- I just want to have fun and work"

XLI15 "all right not scared"

Boys
OLN09 "I am looking forward to maths. No, nothing worries me

OLU11 "I feel happy about going to (school), nothing worries me"

One boy was particularly impatient:

XLI14 "I want to go up now"

A large number of pupils mentioned the attraction of new lessons, joining clubs or making new friends:

Boy
OLU06 "I'm looking forward to all the new lessons"

Girls

OLN05	"I am looking forward to the clubs"
UNW06	"I (am) looking forward to making new friends and having different lessons"

Some of the pupils qualified their written comments with reservations about "getting lost" (4 boys, 6 girls) or "getting beaten up" (1 boy, 2 girls). One girl, in her written responses, was worried about "exams and homework" (OLI10) and another girl had concerns that "I might not do very well" (XLD08). There were, however, only a couple of totally negative comments:

Boy

XLI23	"I am not looking forward to going to my second(a)ry school"

Girl

UNW28	"I am going to miss all my friends"

Expectations of lessons, homework, teachers and teaching style

Generally, there was little difference in the range of responses from cohort and non-cohort pupils. Commenting on lessons, five cohort pupils made fairly positive comments:

Boys

OLI04	"better lessons"
OLI12	"how friendly the teachers are"
OLN09	"fun lessons, teachers"

Girls

OLU09	"it was much more better lessons"
UNW15	"The teachers are nicer than I thought, the work was easy sometimes"

One girl (XLI20) thought that the teachers were "much more striked (strict)"; two non-cohort girls gave very different comments on their new teachers: "the teachers are much nicer than I thought" (FG26), "the teachers were as bossey as I expected" (FG31). Both cohort and non-cohort pupils had comments to make on the differences:

Cohort pupils

Girl

XLD03	"I did not no (know) that you had all diff(e)rent lessons"

Boys

XLI03	"you had to go to different lessons"
XLI09	"the classes were very different"
XLI18	"more teachers than I expected"

Non-cohort

Girls	
FG03	"two teachers for some subjects"
FG08	"some lessons are more boring"
FG31	"The lessons were more stranger than I expected"

Four pupils provided a bit more detail:

Cohort

Boys	
UNW09	"we do more writing than I expected"
XLD15	"science is different, English is different"
Girl	
OLI02	"we had German, French & Science"

Non-cohort

Boy	
EQ02	"science work is a lot different"
Girl	
FG28	"didn't expect to do German in the first year"

Three other non-cohort pupils also provided comments on lessons or teachers but these comments revealed little about the pupils' attitudes towards them:

Boy	
FG01	"lessons tim(e)s, teachers"
Girls	
FG12	"different teachers"
FG21	"different lessons ev(e)ry hour"
FG23	"lots of different teachers and rooms"
FG46	"lot of new subjects"

One of the non-cohort boys (FG02) did, however, comment that he had found that the lessons were "hard" (as he had anticipated) and another boy thought that they were "harder". Examination of the transcripts of the Year 6 tape-recordings (i.e. pre-transfer) revealed no worries about the "difficulty" of lessons or homework although one cohort pupil (XLI21, a girl) reported that, although she thought the 'new' school would be "exciting", she was "a little bit worried because you are at the top of the school here and there you will be at the bottom".

One pupil (UNW17, a girl) who reported (in Year 6) that she had "no worries" about the transfer, revealed in Year 7 that, although the work in the secondary school had been "a little bit harder", she had thought that the lessons "were going to be much harder than they are". Two other girls (OLU12 and XLI12) both revealed in their Year 7 interviews that the lessons were not as hard as they had previously expected. A boy from the cohort (OLU12) found the "work in maths to be fairly easy" and a girl (OLN06) thought that, in general, the work was "quite easy".

There were 35 comments on lessons (from 15 cohort, and 20 non-cohort, pupils) and this was higher than the number received for any of the other sub-categories. Bearing in mind that the qualitative data were derived from two small groups the difference in the numbers of pupils in the two groups (cohort=71 pupils, non-cohort=85 pupils) is roughly reflected by the number of comments on the lessons by each of the groups (21% and 23% respectively).

'Homework' was mentioned by 11 pupils (4 cohort, 7 non-cohort). Three non-cohort pupils made comments which suggested that the homework load was rather less than anticipated: "the homework is not very hard" (FG20, a girl); "not as much homework" (UNW31, a boy) and "less homework than I thought" (FG21, a girl). One cohort girl (OLU12) thought that "we would have more homework" but one boy (XLI23) thought differently: "loads of homework is set".

Three cohort boys (UNW11, UNW29 and XLD16) and one non-cohort boy (FG14) briefly commented on their observations that the "rules" were different in the new school. One non-cohort boy (FG15) commented that, as anticipated, " we wore a uniform".

Expectations about the new site

Four cohort girls (OLI11, XLD01, XLD06 and XLI11), one non-cohort girl (FG21) and one non-cohort boy (FG22) commented that their expectations that the new school would be "noisy" were realised. The non-cohort pupils were from a local primary school and they would have visited the comprehensive school site, via the primary partnership scheme, at the end of Year 6; these pupils (together with the cohort pupils) would therefore have already built up some knowledge of the site.

There were only a couple of responses on the need for movement between lessons; neither of the pupils who made comments on their questionnaires expanded on whether this had created any problems for them:

Boy
FG15 "we kept changing classrooms each lesson"

Girl
XLI25 "we had to move around each lesson"

Twenty-nine non-cohort pupils (18 girls, 11 boys) made comments (Question 2(a)) about the real difference in size between their primary school and the comprehensive being consistent with their expectations:

Girls
FG07 "people are bigger, schools bigger"

FG20 "loads of people who you learn to get along with"

FG43 "really big and loads of people"

Boy
FG35 "it was big"

Thirty-three cohort pupils (21 girls, 11 boys) made similar comments:

Girl
OLU09 "it's big and more exciting"

Boys
UNW03 "it was much bigger which (was what I) expected"

UNW29 "It was very big, a lot of people, better"

XLD02 "It is a lot bigger. More exciting"

Six pupils (5 girls, 1 boy) from the cohort and four girls from the non-cohort, in their responses to Question 2(b), suggested that the new school was not, in fact, as big they had previously anticipated:

Cohort

Girl
OLI08 "I expected it to be bigger"

Boy
OLU11 "it is smaller than I thought"

Non-cohort

Girls
DPP06 "I thought it would be bigger"

FG43 "It wasn't as big as I thought"

One girl (OLU13) commented that her prediction that finding her way around the school would not be too difficult was correct: "Yes it was surprisingly easy to find your way around as I thought". Another pupil (OLN07, a girl) from the cohort commented: "you found your way around after 2 weeks, you got to know people quickly"; other girls expressed relief: "I thought that I would get lost and I didn't" (UNW03); "I thought I'd get lost at the beginning" (UNW10).

Worries about getting lost were revealed exclusively by girls in the tape-recorded interviews. One girl (XLD05) in her Year 6 interview said that she was "a bit worried about getting lost" but, on interview a year later, admitted that these fears had not been realised. Although they had not revealed any worries in Year 6, two girls (XLI11 and OLI05) revealed a year later that they had been worried that they might get lost when they moved to the secondary school; fortunately their fears were not realised but one of them (XLI11) admitted to getting lost "a little bit" Another girl (XLI24), who had not previously expressed any worries, reported in her interview (Year 7) that she had "got lost four times and was late for French".

One cohort pupil (XLI14, a boy) and two non-cohort pupils (UNW 24, a boy; FG12, a girl) commented on the increased number of classrooms but another non-cohort girl (OLU01) noted: "the classroom's are quite small". Amongst the cohort pupils, there were two mentions (both by girls UNW25 and XLD11) of "corridors" as something which was different in the new school, one boy (OLI05) commented: "....quite big....a lot more people. You get pushed around a bit in corridors". One boy (UNW01) commented that, in the new school, you had to "bring your bag round with you" and one girl (OLI03) found the new school "a lot more tiring than I expected".

The school day and opportunities for sport/clubs

There were only three comments (2 cohort, 1 non-cohort) on the pattern of the school day and that morning breaks and lunchtimes were different. The availability of a Tuck Shop received three mentions (one cohort, two non-cohort). There were surprisingly few mentions of the availability of a large number of lunch-time and after school clubs; one boy (FG25) commented on the facility for playing tennis on an all weather pitch and a girl (OLU07) commented simply: "clubs".

Fear of bullying or other personal problems

One boy (XLI05) and two girls (OLN06 and XLI20) in the original cohort had expressed some concern about "getting beaten up" but none of these pupils made any comments about bullying on their Year 7 questionnaire. However another girl in the cohort (XLD05) referred to "the bullies" in her response to Question 2(a) and one boy (XLD13) commented: "I thought there would be one big bully". Three boys had comments about some less serious behaviour:

XLD18	"The people are the same pushing you around"
XLD13	"That whoever (is) older bosses the younger year around"
XLI19	"same as I thought with bigger boys not picking on me"

None of the pupils who transferred from non-participating primary schools commented on bullying; two girls had positive comments about making friends:

OLU10	"friendly"
DPP03	"easy to make friends"

One girl, who had not expressed any concern about this in Year 6, admitted on interview (Year 7) that there were "a lot of bullies" and admitted to being bullied herself. Another girl (XLI11) revealed in her Year 7 interview that she "expected bullying, but there wasn't" and one girl (XLI20) and one boy (OLN09) said that they had experienced some form of bullying but this had now been successfully resolved.

Parental responses on experiences of, and attitudes towards, science

1. Parental comments on their primary science education (Chapter 9.2.1)

(i) Mothers

OLI04	"I did not actually have any science tuition at school (Scottish Educational System)"
UNW08	"To my knowledge no science was covered at Primary School"
XLD23	"I do not believe we did hardly any science at all"

Where the mothers made specific comments about primary science, these comments were entirely devoted to 'nature study' or similar:

OLI05	"We did not do any science apart from natural history"
OLN04	"...we did nature studies, but no real experiments as such..."
OLU09	"I can only remember some nature study work and biology lessons. I cannot remember any experiments or other science"

One mother also cited radio programmes as providing a positive stimulus:

OLI01	"I particularly enjoyed nature walks and BBC radio programmes (1957-64)".

(ii) Fathers

A couple of fathers (XLD06 and XLD22) admitted to not being able to remember much about their primary science education:

XLD22	"I cannot remember very much!"

However, one father who recorded that he had not done any primary 'science' revealed in his qualitative comments that he had enjoyed the 'nature study' programmes:

UNW09	"Apart from Nature Study, which I enjoyed, there was no primary science. One of the memorable highlights of primary school was the BBC radio series 'How Things Began' "

'Outdoor nature studies' was the only topic which was specifically mentioned in the fathers' comments:

XLD20	"I enjoyed being out and about, collecting flowers for analysis etc. I found it interesting".
OLI10	"I liked outdoor investigations"

Four fathers demonstrated positive attitudes to their primary science:

OLI03	"very worth while subject"
OLI08	"enjoyed the subjects"
OLU09	"Our science was linked to life which made it relevant"
XLI15	"it was a fun time"

One father had some reservations: "hands-on experiments were always interesting but the theory was a bit long-winded" (XLI12).

2. Attitudes to secondary science

For the 39 pairs of parents who responded to this question, 18 fathers had more positive scores than their wives/partners; in only 9 couples did the mother record a higher score than her husband/partner. Twelve couples had the same scores. Compared with their recollections of primary science (where only 3 fathers recorded more positive scores than their wives/ partners) secondary science seems to have made much more of a positive impression on the fathers than on their wives/partners.

The fathers' attitudes were generally more positive (skewness statistic: -1.145) and negative scores ('1' and '2') were recorded by only 7.5% of the fathers who commented on their attitudes to secondary science. A much higher percentage of mothers (13.95%) however, gave negative scores of '2' ("didn't like very much") for their recollections of secondary science (none of the mothers recorded the lowest score, '1'). The skewness statistic for the mothers was -0.463.

3. Level of parental science education and occupations

When the occupations[7] outside the home of the parents who had studied one, or more, science subjects beyond age 16 (but not beyond 'A' level) were examined, one of the mothers (who studied biology at 'A' level) was working as a ward sister and another mother, who had also studied biology at this level, was employed as a medical receptionist. One mother who had studied chemistry post-16 was working as a medical secretary. Two mothers in this category did not specify their occupation but most of the other mothers who had studied science post-16, but not at degree level, were in clerical or administrative positions.

Six of the fathers who had studied one or more of the sciences up to 'A' level (or equivalent), had science-related occupations at the time of the enquiry. One father, who had studied physics, was an energy advisor; the other fathers were in supervisory or managerial posts.

[7] as reported in 1996

Three (6.1%) of the mothers, compared with 4 (9.5%) of the fathers, who responded declared that they had continued to study one of the sciences as part of a degree course or equivalent. The specialisms covered by the three mothers were medical microbiology, nutrition and geography. The microbiology graduate was working as a medical microbiological scientific officer and the geography graduate was a teacher; the nutritionist was a 'mother and housewife'. Four of the fathers who had studied one or more post-'A' level sciences were graduates (one of whom was medically qualified). Apart from the doctor who was practising as a G.P., the other three were graduates (in microbiology, physics and electrical engineering) working as a technical representative, in computing and as a financial advisor respectively. Two fathers who had studied science beyond 'A'-level or equivalent, but who were not graduates, were employed as a mechanical service manager and the other was a sales consultant.

4. Parental 'tinkering' during the secondary years of education

Some of the examples of 'tinkering' which were provided on the parental questionnaires are shown below:

Maternal comments on "tinkering" during secondary years

Boys	
OLI01	"helping my father (electrical engineer) in his workshop. Learning basic electrical wiring".
XLD06	"father makes miniature engines - used to give a 'helping hand' and car maintenance".
XLI21	"took clocks + watches apart, but couldn't put them back together, but still good fun!"
UNW21	"mixing colours together. Finding colour changes and texture on fabric and synthetic material".
Girls	
OLI04	"enjoyed dissecting animals, making various products in biology. Enjoyed the study of insects".
OLN03	"mainly using my brother's Lego or Meccano to construct things. I remember taking my radio apart to see what it looked like inside".
OLU06	"experimenting with liquid substances to see if they changed colour".

<u>*Paternal comments on "tinkering" during secondary years*</u>

Boys

OLI05	"disassembly old radio, home chemistry set"
OLU06	"motorcycles"
XLD20	"I enjoyed the chemistry experiments producing gases, coloured flames etc."
XLD22	"dissecting insects/worms etc."
XLI09	"taking pen's apart to see how they worked. Model railway's"
XLI23	"motorbikes"

Girls

OLI10	"bicycle/motorcycle, model making"
OLN05	"bunsen burner experiments, magnetism, friction etc.etc."
OLU09	"taking engines apart and making a go-kart from scrap"
UNW15	"model making including aero engines, building electronic equipment-radios etc. motorcycles/bicycles repair and maintenance"
UNW28	"mainly mechanical things/objects. Bicycle parts, engines, watches, clocks"

5. Parental current experience of tinkering

Some of the parental comments are given below:

<u>*Maternal comments on current experience of tinkering*</u>

with daughters:

XLD06	"growing plants from seed, trying not to dig them up as weeds"
OLI01	"gardening-growing vegetables, making compost"
OLI10	"cooking/sewing"
UNW10	"I love cookery and trying new things out and my daughter has begun to 'have a go' as well
XLI21	"when I mend household appliances or plugs etc. I explain what I am doing"
OLU12	"taking plugs to pieces. Repairing things"

with sons

OLU03	"learning about plants e.g. grow seeds and planting"
XLD12	"gardening, cooking etc."
XLD16	"enjoys cooking experiments"
XLD18	"when repairing things...wiring plugs - he watches and has a go. Stain removing, he asks what I use"
XLD21	"bicycles, mowers, farm equipment"

Paternal comments on current experience of tinkering

with daughters

XLD11	"building work"
XLD06	"classic cars – she is willing to help"
OLI10	"computer studies"

with sons

UNW09	"He's interested in pest and disease control in the garden, compost-making techniques and methods of preserving the produce"
XLI14	"watches, diy & car servicing"
OLU11	"helps mend motorbike, car, lawn mower"
UNW07	"helping put together her younger sisters toys"
UNW13	"fixing washing machine/ lawn mower etc."

6. Parental encouragement of children's interest in science

Some of the examples of the mothers' and fathers' comments about their involvement in shared activities are shown below:

Mothers' involvement in shared activities

with daughters

XLI21	"we've done easy experiments at home with vinegar and baking soda, etc, and water fountains (hot and cold waters, different colours) and explain why it works".
XLD06	"encourage her to plant and maintain her own flower/veg. plot in the garden"
OLN04	"discuss scientific issues. Encourage scientific study, visit natural history museums etc. Assist and encourage interest by helping her to use commercial physics and chemistry sets + explanation of natural history".
OLI01	"...watching eclipse of the moon, growing strings of crystals with sugar and salt".
UNW15	"cooking-it's amazing to see the changes that occur using different ingredients and how different ways of cooking can make different changes to the same items".

with sons

OLU03	"weather systems e.g. cloud, what makes plants grow"
XLD21	"walking in forest, working in garden with plants and trees".
OLI04	"make up new recipes, learn all about different chemicals, vitamins etc. Try out items in water i.e. what will float, what will not and why. Try mixing things like oil and water and then finding out why the two do not mix".
XLD16	"cook together occasionally, help with experiments he does from his science books"

<u>*Fathers' involvement in shared activities*</u>

with daughters

OLI10	"computing".
OLN05	"chemistry set experiments"
XLI21	"we do bicycle maintenance together e.g. gears, brakes etc."
XLD06	"classic cars etc."

with sons

OLU03	"model making (plastic kits)"
XLD19	"I rebuild old English motorcycles and (name) sometimes helps"
XLI14	"home computing, involvement around house and garden"
UNW09	"collect insect larvae and watch them going through metamorphosis. Watched recent lunar eclipse and try to name planets and constellations"

7. Parents' reflections on science

Parents were asked, Appendix 4(f), Question 7(a), whether they would have liked to have studied more science (i.e. beyond the level reported in Question 5). Twenty one of the 47 mothers (44.7%) responding to this question would have liked to have studied more science and 25 fathers (55.6% of the male responses) held similar views.

The parents were also asked (Question 6(b)) whether they thought that they used their knowledge of science in their job. Twelve mothers (25% of those responding to the question), compared with 25 fathers (55.6% of the male responses) thought that they <u>did</u> use their scientific knowledge in their current main occupation.

Appendix 11.1

Entries for physics, chemistry and biology at 'A' level and 'AS' level as a percentage of all 'A'/'AS' entries in 1991/2 and 1999/2000 in England, Wales and Northern Ireland (Blair, 2003).

	1991/1992 *Percentage of all entries (including Advanced Supplementary level)*		**1999/2000** *Percentage of all entries (including Advanced Subsidiary level)*	
	Males	Females	Males	Females
Physics	18.75	4.67	17.65	4.24
Chemistry	14.76	9.24	13.80	11.68
Biology	11.88	16.63	14.04	19.85