PUPIL ATTITUDES: A LONGITUDINAL STUDY OF CHILDREN'S ATTITUDES TO SCIENCE AT TRANSFER FROM PRIMARY TO SECONDARY SCHOOL.

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Abstract

This thesis examines pupils' attitudes to science as they move from primary to secondary school, and seeks to identify any factors that might influence these attitudes.

A review of the literature on attitudes to science research finds that existing studies with similar aims have tended to use cross-sectional samples, many of which were small or unrepresentative, and furthermore that there has often been inadequate control of potentially influential variables.

The present work employs a longitudinal study of over 3000 children, between10 and12 years old, from schools in Essex. Data has been collected by means of questionnaires, supplemented by a free response section, and by interviews. Information was also collected from over 300 primary and secondary teachers by means of questionnaires, supplemented by a free response section, and interviews. Information was collected, by interviews and from statistical data in the public domain, about all participating schools.

The integrated data from the children, their teachers and their schools has been analysed in three different ways: the quantitative data was subjected to a variety of statistical techniques to compare the two sets of data from primary and secondary school as two cross-sections, and to investigate changes for individual pupils taking a longitudinal approach. The qualitative data was subjected to textual analysis and it was also integrated with the quantitative data. These analyses yield conclusions, which inform pedagogy, school management, teacher training, and social justice.

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INTRODUCTION

The enquiry into the flow of candidates in science and technology into higher education (Dainton, 1968) described the worrying decline in numbers of pupils choosing to study science in higher education as 'the swing from science'. Ormerod and Duckworth (1975) suggested that this decline might be the result of,

> *A lessening interest in science and a disaffection with science and technology among students* (Op. cit., p.1.).

Since that time, the pace of scientific advance has accelerated. Society is totally infused with, and driven by, science and technology. But in spite of dramatic breakthroughs in almost every discipline, public attitudes to science do not appear to have changed appreciably. In 1995, only 46% of Britons believed that 'science benefits more than it harms' (POST, 1995), and in 2000 a survey found that only 43% agreed that 'the benefits of science are greater than the harmful effects' (Wellcome, 2000). The Wellcome survey also reveals that negative responses to science are associated with science sponsored by Government or industry, and with science whose purpose is not overtly beneficial. These negative responses are expressed as lack of trust.

During the same period the steady decline in the proportion of students choosing to study sciences post-16 has continued. The political response to this trend was to provide all children with a broad science education until the age of 16, via the introduction of, first, GCSE balanced sciences in 1986, and then in 1988 via a science National Curriculum for all children from 5 to 16 years of age. These changes have led to a steady increase in the numbers of pupils entering for science examinations and being successful in them.

But despite the increase in the proportion of students gaining grades A-C at GCSE level, figures show that the proportion of the A level cohort choosing to study the sciences has fallen steadily since 1985 (DFE, 1994). Government has chosen to focus on the raising of standards of achievement in science rather than on attitudes towards science. Since students are being more and more successful in science examinations, it seems unlikely that they reject further study of science because of their lack of appropriate qualifications. Instead, such a choice is likely to stem from negative views of science, and this leads one to ask: when and why do such negative attitudes develop?

Although the relationship between attitudes and post-16 choices has been recognised and studies of attitudes to science have been conducted over recent years (e.g. Sears, 1995; Woolnough, 1994a and 1993), these studies have concentrated exclusively on students aged between 15 and 17 years old, at the time when final decisions about post-16 choices are made. The problem with studies of this nature is that they may well concentrate on attitudes *after* they have become fixed. It is believed that attitudes are very hard to change once formed (Eiser, 1994) and that children may form their attitudes to science at a very early age (Davies and Brember, 1994; Newton and Newton, 1992; Ormerod and Duckworth, 1975).

Since the introduction of the National Curriculum the foundations of an interest in science have been laid at primary school. From the age of 5 years, all children in primary schools are now exposed to science and also to their teachers' views about science. Yet most primary teachers have limited science qualifications, and are therefore likely to lack confidence in teaching science. So it might be thought that the disaffection with science begins in primary school, and yet research indicates that attitudes to science decline *after* the transfer to secondary school (e.g. Keys et al, 1997a & 1997b, Doherty and Dawe, 1985). Perhaps some important changes occur around the time of transfer.

It has been suggested that there is a major difference between primary and secondary teachers, both in teaching style and in perceptions of their role in teaching science, (e.g. Education Committee, House of Commons, 1995; Spears, 1988), and that teachers' own beliefs about science may influence the attitudes of the children they teach (e.g. Brickhouse, 1991). Furthermore, the time of transfer to secondary school has been cited as a cause of major disruption in children's educational, emotional and social development (e.g. Galton, 1983; Plowden, 1967). Thus, the time of transfer from primary to secondary school seems to be a crucial point at which to investigate attitudes to science.

Do children's attitudes to science change as they move from primary school to secondary school? Despite major changes in science education in the last 20 years, the answer to this question still rests on a research study carried out in Scottish schools in 1981 (Hadden, 1981). The question is asked again now in order to reassess some fundamental issues in the light of recent changes in science education: how do children feel about science at school, does transfer have a negative effect on their attitudes and what factors affect these attitudes?

The lack of more recent quantitative evidence means that statements such as the following are generally accepted:

> *Research shows that in transferring from primary to secondary school many pupils lose momentum –or even regress educationally. (Barber, 1999)*

> *I have seen primary heads almost in tears when their bright, confident, self-sufficient Year 6 children become under-stimulated secondary pupils sitting in rows. (Adey, 2001)*

> *It is sad that more children seem turned off science by the formal subject, laboratory based lessons than are turned on - particularly girls! (Watkinson, 1992, p.8.)*

But to what extent do these statements provide a realistic picture of science education at the time of primary-secondary transfer? It was in an attempt to explore this question that this research was undertaken. The essential questions for this study are therefore:

- Are there any quantifiable changes in children's attitudes to science as they move from primary to secondary school?
- To what extent does the approach to teaching science change on transition from primary to secondary school?
- What factors affect children's and teachers' attitudes to science?

Although the subject of this research is apparently not new, much has changed since it was last studied: the development of the concept of primary-secondary transfer, the major historical, political, scientific and educational influences on science education, and the changes in attitude theory and attitude measurement may all affect the relevance of much of the earlier research into attitudes to science. Chapter 1 sets the scene by describing the historical context of the study. The existing research literature extends over a large time period, going back to the first half of the last century, and covers three separate areas: attitudes to school, to science and to transfer. In Chapter 2 the review of this literature examines these three separate areas, focusing on their relevance to the present study in terms of historical context and methodology. Three methodological issues arise from this review: first, the lack of longitudinal studies and the dependence on cross-sectional studies for evidence of change in attitudes; second, the apparent inter-relationship between attitudes to school and attitudes to science; and third, the researcher's choice of quantitative or qualitative methods.

These three issues had a major influence on the design of the present study, and so the arguments surrounding them are reviewed in Part 1 of Chapter 3. Theoretical perspectives and methodologies are there critically discussed in order to develop a suitable model for an exploration of attitudes to science at the time of transfer. The design that emerges is a large-scale longitudinal study, with both quantitative and qualitative aspects. The methods chosen are tried and tested ones, but they have not been applied to this topic before. The detail of these methods is laid out in Part 2 of Chapter 3.

In Chapters 4 to 7, data from the study are presented and analysed in different ways. In Chapter 4 the data is treated as two cross-sections, and comparisons of attitudes are made between quantitative data gathered in the last year of primary school and the first year of secondary school. Although much previous research has taken this approach, the effects of other important variables on attitudes to science have been largely ignored; this aspect is dealt with in Chapter 5 by means of regression analysis.

The qualitative data is reported and discussed in Chapter 6, using textual analysis of children's written comments to make comparisons between the two years.

In Chapter 7, the longitudinal data is used to investigate individual changes, and the factors that are linked with these changes. This longitudinal approach is similar to that taken by Hadden (1981), but different statistical methods are used in the analysis of the present data. (A comparison of the cross-sectional and longitudinal results appears in Appendix 9.)

The thesis concludes, in Chapter 8, with a brief account of the main findings of the study, suggestions for future work, and the relevance of the research to science teacher education.

Where this thesis has sought to make an original contribution is in the use of three different methodological approaches to provide fresh insights into teachers' and children's attitudes to science on transfer from primary to secondary school in a new educational system. It is hoped that the findings of the study will provide a pertinent and timely resource that may assist and inform future science education policy discussion.

CHAPTER 1. THE HISTORICAL CONTEXT

1.1 The years of definition: 1926 – 1967

This summary of events surveys the situation up to 1967, dealing with the introduction of the process of 'transition' and the consequent concepts of 'continuity', 'liaison' and 'progression, and with the parallel developments in attitude research. It is accepted that this is only part of a much larger picture, the development of British education in the 20th century, but it is essential to focus here on the particular issues on which this research is based.

1.1.1 THE CONCEPT OF TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

Transition may be defined as a *'passage from one place, state, stage, style or subject to another'*, (The Chambers Dictionary, 1998). In the course of the twentieth century, the term has come to define any one of the critical periods in the process of schooling, when an individual moves from one stage to the next. For example, the move from one school to another, (from primary to secondary, from junior to middle, or from secondary school to a sixth form college), is often described as a transition. Transition is also used to describe stages *within* individual schools, such as the move from infant to junior school within a primary school, or the move from GCSE courses (generally from 14 to 16 years of age) to sixth form studies (post-16) within a secondary school. In the context of the present study, transition will refer to the move from primary to secondary school at age 11.

All transitions share a common feature - a period of discontinuity. In particular, educational transition has been compared to the process of changing jobs (King Rice, 1997), so transfer to secondary education could be regarded as a discontinuity in the work environment, with its consequent changes in expectations and values within the new social structure. Although it is inevitable, when changing schools, that there will be a change in the physical environment, other changes will be dependent upon the ethos of individual schools and upon the accepted conventions of the day.

The opportunity for transition from primary to secondary education is relatively new. Prior to the 1918 Education Act the majority of children in Britain attended elementary school until the age of twelve, and subsequently up to the 1944 Act, to age fourteen; but only more privileged families had access to 'secondary' schooling, for which fees were charged. However, political interventions over little more than a single generation have changed the character of education in England and Wales in this regard.

It was R.H.Tawney, in his comments on secondary education in the 1920s who made the first suggestion of some form of secondary education, following primary education, for all children. Tawney became a member of the Hadow Committee, and is regarded as the moving spirit behind its subsequent report *The Education of the Adolescent*, in 1926. That Report states:

> *We therefore propose that all children should be transferred, at the age of eleven or twelve, from the junior or primary school either to schools of the type now called secondary, or to schools (whether selective or non-selective) of the type which is now called central, or to senior and separate departments of existing elementary schools.* (Hadow, 1926, p. xix, quoted in Maclure, 1968, p.180.)

A later committee, chaired by Hadow, in 1928 was asked to 'inquire into and report as to the courses of study suitable for children...up to the age of 11' (Maclure, Op. cit.). This second Hadow Committee (1931) recommended that 'the curriculum is to be thought of in terms of activity and experience rather than of knowledge to be acquired and facts to be stored'. So, having established the idea of transition and two stages of education, the Hadow Committee's second report foreshadowed the Plowden Report (1967) in suggesting two different types of education at these two stages. The Committee's advocacy of close co-operation between the teachers in primary and secondary schools, and the view of education as a *continuous* process presaged the later recognition of the problems of continuity. Jarman, Keogh, and Naylor define continuity as,

> *...consistency in aims, values and expectations, but not uniformity of experience, and it [continuity] suggests that there are no sudden changes in the nature of the learning experience without good reason.*(Jarman, Keogh, and Naylor, 1994, p.7.)

This is clearly a difficult state to achieve when a child's education is interrupted by the physical move to another school. Continuity has generally been viewed from two major aspects: curricular continuity, and continuity in the nature of school experience, (often referred to in terms of children's adjustment to their new school).

The change from primary to secondary school has been recognised as a challenging and traumatic time for children from the earliest days of primary-secondary schooling. For example, the Norwood Committee (1943) recommended a common curriculum for the first two years of secondary education, *'In order to ease the transition from primary education to...secondary ...'* (Maclure, Op. cit. p.204.). However, a main concern was the age of transfer to secondary school and a common curriculum was suggested partly to ensure the possibility of later transfer between different kinds of secondary school. In the event, the 1944 Education Act diluted this recommendation, and states that

> *...the different types of secondary school must be 'broadly equivalent...*[and that] *...the free interchange of pupils from one type of education to another must be facilitated* (quoted in Barber, 1994, p.65.).

With the 1944 Act the clean break at eleven was approved and the idea of education as a *continuous* process was promoted as an important goal for the first time[1]. Discontinuities in the physical environment and in social structures are an inevitable result of transition, and nowadays schools attempt to deal with such problems by means of a variety of liaison strategies. For example, induction visits are arranged for primary children to their new secondary school during their last term at primary school, and often secondary school staff and pupils visit primary schools in advance of the transition. Before 1967, formal liaison between primary and secondary schools was uncommon. However, the Plowden Committee (1967), which was set up *'to consider primary education in all its aspects, and the transition to secondary education'*, made some far-reaching recommendations: the Report advocated liaison strategies designed to reduce the level of discontinuity at transition (in terms of both pupil adjustment and curriculum continuity), induction visits for children from primary schools to their new secondary schools and visits to secondary schools by parents of new intake should be planned to help children adjust to the new schools, curricular continuity was to be promoted by transferring folders of children's work from primary to secondary school, and by contacts between primary and secondary school (including teachers' visits, meetings and

[1] It could be argued that the 1944 Act in fact caused considerable curricular discontinuity, partly because primary school pupils spent a good portion of their final year preparing for the 11+ examination, to the detriment of the recommended experience-based work; and also partly because at secondary school they were introduced to new subjects such as Latin (in grammar schools) or craft-based work in secondary modern and technical schools. This curricular discontinuity diminished when comprehensive education became the norm, but recent reports suggest that it is re-emerging in another guise as a result of preparation for Key Stage tests. This idea is discussed later on p. 52.

joint in-service training). These aspects of the Plowden Report were quite widely adopted and are now common features of the transfer process. However, Bernstein and Davies (1969) speculated *'upon the possible mechanics and consequences of keeping such folders'*, the problems of who would write them up and control them, and the difficulties of confidentiality and access, and such issues have continued to be problematic in primary-secondary liaison.

The Plowden Committee also advocated *' a new approach.'* summarised as *' learning by discovery"*, based on earlier suggestions (Hadow,1931). Bernstein and Davies (Op. cit.), in a critique of Plowden, spoke of the *'far reaching implications'* of the experiential learning approach. It was their opinion that the gap between primary and secondary schools would be *more* difficult to bridge, since transfer of information would become more, rather than less, problematic. As they put it:

> *It crucially heightens the problem of the evaluation of children's progress and that of the pedagogy itself. It will serve to reduce the salience of traditional attainments in the evaluation of children. Pupil success will be defined less sharply in terms of the efficient recall of conventionally taught material.*
> (Bernstein & Davies, 1969, p. 78)

This illuminating commentary goes to the heart of the problems of transition when it speaks, crucially, of the evaluation of children's progress and success. This period, the mid-'sixties, marks the beginning of much research into 'transition' issues: the particular problems associated with transition, the liaison strategies, and the changes in pupils and for pupils around the time of transition from primary to secondary school. During the years following the publication of the Plowden Report, the main emphasis for schools was on providing strategies to assist pupil adjustment to secondary school experience. However, curricular continuity received much less attention, and the idea of curriculum progression was in its infancy.

Progression is concerned with moving the child forward within the curriculum, through increasing maturity of approach, to a better understanding of concepts and increased factual knowledge. The Plowden Report devoted a whole section to the primary science curriculum, noting initially that,

> *Traditionally, the only science taught in primary schools was nature study.....* (Plowden, Vol. 1, p240).

However, it welcomed *'the introduction of a greater variety of subject matter into primary schools'* , (Ibid., p241), and in particular the (limited) introduction of the Nuffield Junior School Project in 1965. The Committee recognised that developments in primary science might have negative, as well as positive, impacts upon secondary sciences. As they put it:

> *The development [of primary science] has not been greeted with unanimous enthusiasm in all quarters. Some teachers of science in secondary schools have feared that children would come to them possessing all kinds of fragmentary, unclassified information, some of it inaccurate or at least "unscientific", all of it incomplete.* (Ibid., p244)

It was also hoped that secondary school science teachers would recognise the value of equipping children at primary level with the means,

> *....to proceed with a scientific education. We believe that many secondary school teachers of science welcome this already and we hope that soon all of them will do so.'*(Ibid., p. 244).

Thus, the development of primary science was encouraged, and so continuity and progression from primary to secondary science became transition issues. During the following years there was considerable growth in primary science, and consequently it became a new focus for research on transition from primary to secondary school.

1.1.2 THE GROWTH OF ATTITUDE THEORY

The concept of attitude as an important determinant of behaviour was in its infancy when the first Hadow Report was published in 1926. The following years saw a proliferation of definitions and theories of attitude as well as of methods of attitude measurement. Since the concept of attitude was identified by Allport as, *'the most distinctive and indispensable concept in... social psychology'"*(Allport, 1935), there has been much disagreement concerning the production of a single, all-encompassing definition. Allport recognised this controversy and stated that,

> *Within the past fifteen years the doctrine of attitudes has almost completely captured and re-fashioned the science of social psychology. The nature of attitudes, however, is still in dispute, and it may correctly be questioned whether a science raised upon so amorphous a foundation can be strong. (Allport, 1935, p.839.)*

Indeed, he gave *sixteen* examples of "representative" definitions. Allport's own definition of attitude in 1935 was:

> *...a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related (Op. cit., p.8)*

This is not very far removed from some more recent definitions, such as:

> *...an attitude is a state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli. (Oppenheim, 1992, p.174.)*

It might appear that there is some degree of agreement about the broad definition of attitude. However, the above definitions indicate a relationship between attitude and behaviour, which other later definitions do not. For example:

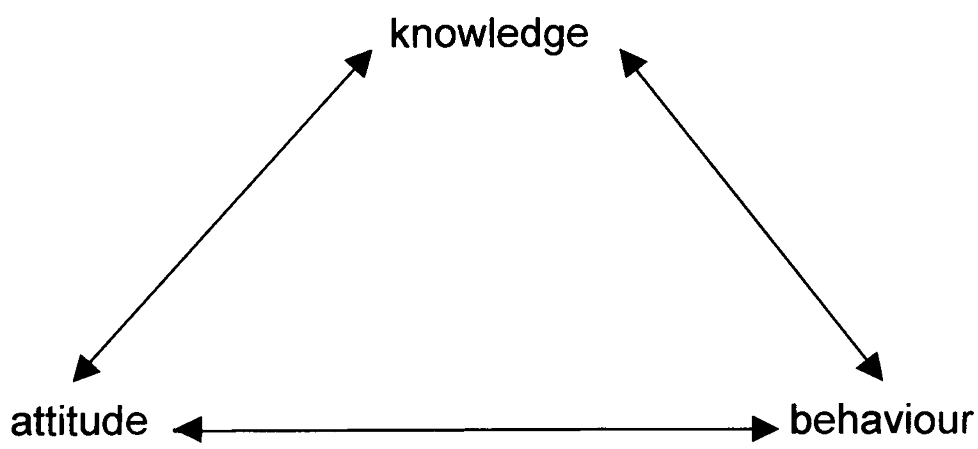
> *Attitudes are likes and dislikes, favourable or unfavourable evaluations and reactions to objects, people, situations or any other aspect of the world, including abstract ideas and social policies.* (Atkinson & Hilgard,1996).

Or, an even more general definition:

> *...an attitude is an evaluation of some object about which an individual has some knowledge* (Pratkanis & Greenwald, 1989)

Attitude was originally regarded as an important concept in social psychology because of the suggested link between attitude and behaviour. Consequently, the advertising industry was an early driving force in the development of attitude change theory. For example, in the Yale research group (Hovland, Janis and Kelley) approach to attitude change (Zimbardo et al, 1977), the attitude (favourable or unfavourable reaction) is influenced by altering beliefs through persuasive communications. This approach, along with many other more formal theories, derives from the view that knowledge, attitude and behaviour are closely linked in a triadic relationship, represented in Figure 1.1 below.

Figure 1-1: Model of the triadic view of attitude, knowledge and behaviour



As we will see, recent work has challenged the idea of a direct relationship between attitude and behaviour. However, early work also contributed considerable evidence to suggest that attitudes might not be directly linked to behaviour, the most famous example being the work of Lapiere (1934). Lapiere accompanied a Chinese couple on successful visits to various restaurants and motels. Later, he wrote to the same establishments asking if they would accept a reservation for a party including Chinese people. Many of those who had given hospitality to Lapiere and his Chinese friends replied that they would not accept the booking. Consequently, some theorists defined attitude change in terms of two components: affective and cognitive, arguing that behaviour should not be regarded as a component part of attitude.

Although earlier research had looked at the effects of persuasion on behaviour, later in this period, 1928-1967, research concentrated on understanding the relationships between attitudes, behaviour and social influences. This research led to the development of a variety of theories to explain attitude changes in terms of behaviour and social influence. Two particular groups of theories tried to explain such effects; consistency theories and social learning theories. The first of these, consistency theories, suggest that attitude changes occur because of a basic personal need to maintain consistency of one's own attitudes with either one's own behaviour or with the attitudes of other people.

Consistency theories, such as those of Heider in1946 and Festinger in 1957 postulated a basic need for consistency among attitudes or between attitudes and behaviour (Zimbardo et al, 1977). These theories assumed that the presence of an inconsistency produced psychological discomfort and in order to reduce this an individual would alter their attitudes to produce consistency. One of the first of these attitude change theories was Heider's balance theory (1946). In this theory, three elements are involved, forming a triad: the triad consists of two people (P and O) and either a third person or the attitude object (X) making up the third part of the triad (Figure 1-2).

Figure 1-2: Some examples of Heider's attitude triads

Balanced attitudes	P + + O + X	P + - O - X	P - - O - X	P - - O + X
Unbalanced attitudes	P + - O + X			

Triads can be balanced or unbalanced, in terms of attitude. There is balance within the triad as long as the attitudes are balanced + denotes a positive attitude between two of the triad and - denotes a negative attitude between them. In this theory Heider attempted to explain the changes in attitude taking place when two or more people operate together. A balance in attitudes would only exist when all members of the group had the same negative or positive character. Thus, if you (P) like your best friend (O) and your best friend likes science (X), then you should like science. If you do not like science, then the triad is unbalanced. At that point, you change your attitude so that you do like science, or you deny that your friend likes science, or you alter your opinion about your friend.

An extension of the balance theory, proposed by Newcomb in 1961, concerned the strength of the social and psychological bonds between people.

Newcomb predicted that the extent of attitude change depended upon the bonds between the people involved. Attitudes would change as the strength of the relationship changed, and individuals tried to reconcile conflicting attitudes.

According to Festinger (1957) individuals also try to reconcile conflicts between their attitudes and their own behaviour. Festinger's Cognitive Dissonance theory is one of the best known of the consistency theories, the main elements of the theory are as follows:

- Attitudes & behaviour can be inconsistent (dissonant)
- Dissonance is physiologically arousing & uncomfortable

Dissonance can be reduced through changing dissonant elements: most easily changed are attitudinal, rather than behavioural elements.

A powerful source of inconsistency can occur between an individual's self-attitude and self-perception of their behaviour. For example, if an individual says 'I am good at science' and 'I don't get good marks in science' these are dissonant elements and the individual would be motivated to reduce the dissonance by altering the attitude to science, or by working to improve their marks. According to the theory the attitude is the more likely to change.

Thus the theory of cognitive consistency suggests that people organise their attitudes so that they contain the minimum possible sources of contradiction. Cognitive dissonance only occurs when the person has a free choice, when there are unpleasant consequences and when the person knew the consequence when they made the choice to behave in a particular way.

The second group of theories proposed at this time, considered the effects of social learning on attitudes. Attitudes may be acquired or changed through social learning and social comparisons. Social learning includes classical or instrumental conditioning and observational learning or modelling. Classical conditioning studies showed that when initially neutral social stimuli are paired repeatedly with positive or negative stimuli, subjects developed positive or negative attitudes toward the previously neutral stimulus. Instrumental conditioning occurred when individuals were rewarded for expressing the "correct" attitudes. However, observational learning or modelling happens when individuals form attitudes by observing and then imitating models they like and admire. Thus, behaviour may or may not be consistent with attitude depending upon the social pressures operating, and may change in order to correspond to social norms; the attitudes and behaviour of peer groups and family are likely to play a major part in the development of overt behaviour. Therefore, behaviours such as naming science as a preferred subject choice or as a career may be very closely related to the attitudes, beliefs and behaviour of parents and/or peer group.

In the outline above the underlying theme is that attitudes themselves serve a useful function; that of organising our beliefs, values and knowledge.

The idea that attitudes serve certain functions, and that certain needs or motives activate and direct attitude functioning, was developed during the period from1930 to 1960; in 1960 Katz described four basic functions of attitude:

- Ego-defensive – allows people to protect themselves from unpleasant realities.
- Instrumental – enables people to maximise rewards in their environment and to minimise punishments.
- Value-expressive – allows people to express their personal values and self-concepts.
- Knowledge – enables people to make sense of their experiences.

In consistency theories, the ego-defensive function is the principal function served: where a positive self-attitude protects the ego by promoting a positive self-image. On the other hand, social learning theories emphasise the instrumental function. Attitudes take into account the social pressures operating, holding attitudes similar to those of friends, family or peer group allow one to maximise social approval.

Attitudes supply a standard 'frame of reference' for organising and simplifying people's perceptions of an often complex or ambiguous informational environment. (Eagly and Chaiken, 1993). Thus, stereotyping is an integral part of the knowledge function, which help people to simplify their social perceptions and understand the world more easily. For example, gender stereotypes function very powerfully to shape an individual's expectations of others and their own behaviour (Basow, 1986).

Later, theories were developed which attempted to bring together some of the ideas discussed above, and these will be reviewed in the next section.

As attitude theories were developed, so too attitude measurement methods began to proliferate. Thurstone, in his seminal paper, 'Attitudes can be measured' (1928), defined opinion as ' a verbal expression of attitude', and believed that opinions could be used to measure attitudes. Likert (1932) offered two definitions of attitude: *'first, that attitudes are dispositions toward overt action; second, that they are verbal substitutes for overt action.'* His preferred choice was the first. He agreed with Thurstone that attitudes can be measured: '*attitudes are regarded as an indirect method of measuring dispositions'*. Both Thurstone and Likert were agreed that verbal opinions could be used as a measure of attitude and this view forms the basis of most contemporary attitude questionnaires.

Thus, in 1967, research into changes in attitude at the transition from primary to secondary education was set to develop rapidly, and this research is the subject of the next section.

1.2 The years of development: 1967-1987

This period fostered much research into the effects of transition. Indeed, the first major study of transfer, (Nisbet and Entwistle, 1967) reported the first part of its findings as the Plowden Committee was meeting. Subsequently, a number of other studies investigating the effects of transition on children's attitudes were published; this research will be critically reviewed in Chapter 3. During this same period there were substantial developments in science education: new schools of thought about education and science emerged, and there was curriculum development at both primary and secondary levels. This was also a time of increasing political intervention, leading, at the end of the 1980s, to the introduction of a National Curriculum for science for all children aged from 5 to 16 years. Each of these aspects, educational and political, has had its effect on the transition from primary to secondary school, and it is in consideration of these effects that the two areas of educational change and curriculum change, will now be briefly reviewed.

It was also during this time that attitude theory and measurement were refined and combined, and studies of attitudes to school and to science flourished. Therefore, the final part of this section will consider these major changes in attitude theory.

1.2.1 CHANGES IN APPROACH TO SCIENCE EDUCATION

The ideas of Piaget (1896-1980), which were not widely recognised until the 1960s (Boden, 1979), had a powerful influence on the Plowden Committee. In Piaget's view, intellectual development was characterised by a series of stages, and each stage was held to lay the foundation for the next. These stages were thought to be linked to particular age ranges. For example, the ability to perform 'concrete operations' was linked to the age range 7 to 11 years, and the more abstract concept-forming stage was associated with the age range 11 to 15. Accordingly, children at primary level might be expected to investigate a real, practical situation and understand the use of fair testing in that context, but would not have developed sufficiently to think in abstract terms. This later developmental stage was associated with the age of secondary schooling. Piaget's idea of an essential difference between stages inevitably strengthened the discontinuity in styles of teaching and learning on transfer from primary to secondary school.

A decade on from the Plowden Report this difference in style of teaching at primary and secondary levels was still evident, as this definition of science studies to be included in the primary schools curriculum demonstrates:

> *The emphasis will be on developing the right attitudes to scientific work rather than acquiring a formal knowledge and understanding of any prescribed areas of subject content. This is not to say that by the end of this phase a pupil will not know any science, but merely that this individual store of knowledge and experience will be idiosyncratic and highly personal. We believe this is as it should be, and would provide the basic interest and motivation for the more formal study of science in the later stages of general education. (ASE, 1979, p.42).*

Although such an approach might well have increased the motivation to pursue school science and raise expectations about secondary science, it was unlikely to reduce perceived differences in style on transition to secondary school.

However, Piaget's theory was not the only one under consideration at this time, and in 1978 Novak presented a variety of research studies, which indicated:

> *...no evidence of 'stages' of cognitive development over the age range six to twenty-plus, but rather evidence of cognitive development manifested as a broadening array and elaboration of specific concepts. To the extent that broad, widely relevant concepts are differentiated over time, older subjects show more facility for learning new, relevant concepts, and hence a generalized increase in competence for abstract reasoning is manifest.* (Novak, 1978, p.26.).

He also proposed Ausubel's theory of cognitive learning as more relevant for science education. In Ausubel's view learning should be meaningful, and such 'meaningful learning' is dependent upon a range of variables. These learning variables, falling into two groups, intra-personal and situational, are briefly outlined below.

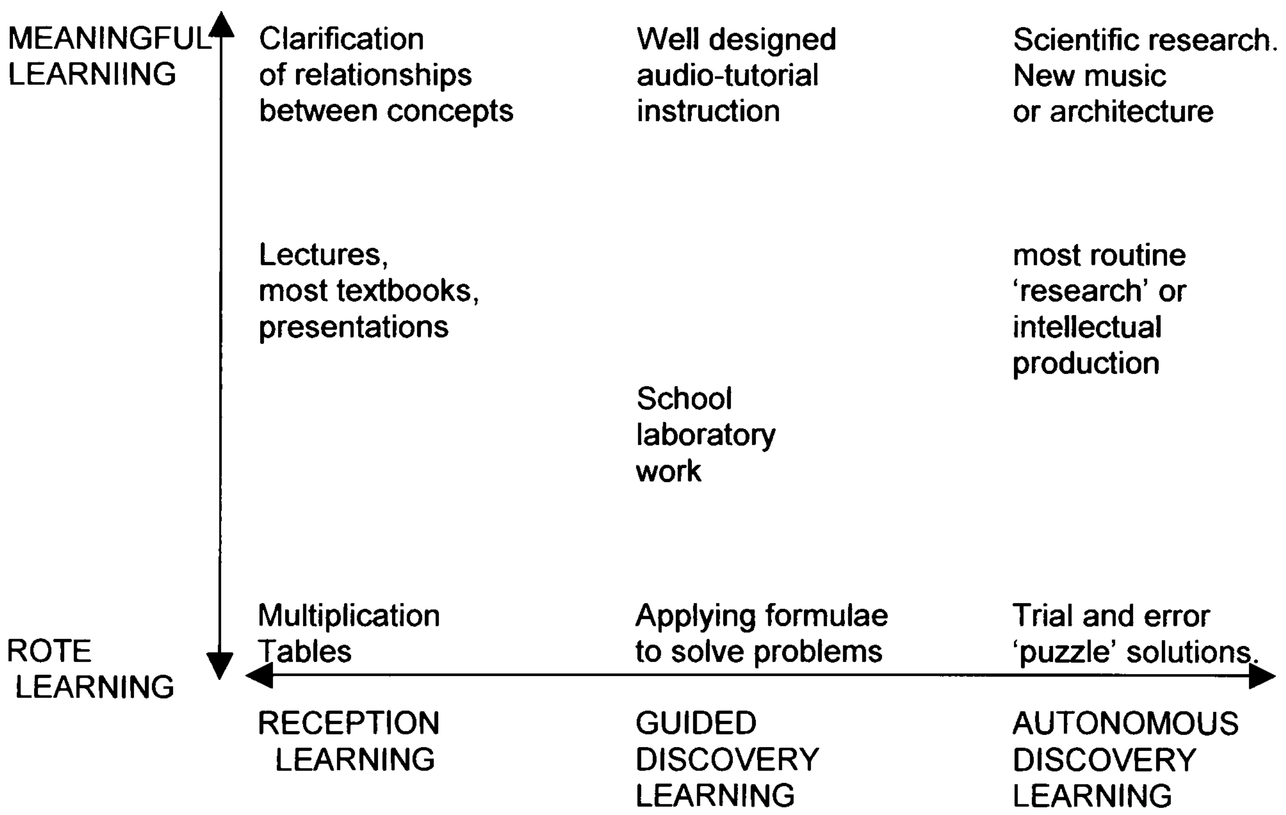
Intra-personal variables	Situational variables
• Previous knowledge	• General school practices
• Developmental readiness	• Instructional materials
• Intellectual ability	• Group and social factors
• Motivational and attitudinal factors	• Characteristics of the teacher
• Personality factors	

(Ausubel, Novak & Hanesian, 1978)

In respect of the transition and continuity of learning, probably the most important of these variables is 'previous knowledge'. Accordingly, if Ausubel's view was accepted, previous knowledge would be taken into account and secondary schools would build upon the work done in primary schools. Consequently, acceptance of Ausubel's cognitive view should have the effect of reducing problems of continuity.

Ausubel viewed meaningful learning as the clarification and organisation of concepts, and believed that the 'discovery learning' approach, advocated by Plowden for primary level children, did not necessarily guarantee meaningful learning. Thus, Ausubel placed discovery learning along a different continuum from meaningful learning. As illustrated in Figure 1-3, reception and discovery learning are on a continuum distinct from rote learning and meaningful learning. Typical forms of learning are shown to illustrate representative different positions in the matrix.

Figure 1-3: Ausubel's view of meaningful learning



Source: Ausubel, Novak and Hanesian, 1978, Educational Psychology: A Cognitive View. P.25.

Discovery learning was regarded as an appropriate method for primary science, but it was less often used in secondary science, although it was manifested in aspects of Nuffield Secondary Science. So the increase in the use of reception learning, encouraged by Ausubel's theories, had the potential to move the methods of the primary school closer to those of most secondary schools.

Vygotsky (1962), like Ausubel, regarded the organisation of concepts into a more generalised form as essential for cognitive development. However, he also demonstrated that children are more able to clarify and organise their learning if they are given a small amount of assistance. In the example given by Vygotsky, two children of apparently the same mental age, say eight years, (and assumed to be at the same developmental stage in Piagetian terms), were given harder problems to solve than they could manage on their own. When provided with some 'slight assistance', one child was able to solve problems for twelve year-olds. However, another could not progress beyond problems for nine year-olds. The difference between the child's mental age and the level of problem solving reached, with some help, was described as the 'zone of proximal development'. If Piaget's theory of cognitive development was accepted, then work would be set at a level matching the child's expected developmental stage. However, by offering work directed at the child's apparent mental age (or stage), the zone of proximal development was not made use of, and so progress was not encouraged. The essential difference between Vygotsky's view and that of Piaget was stated clearly by Vygotsky:

> *Our disagreement with Piaget centers on one point only, but an important point. He assumes that development and instruction are entirely separate... that the function of instruction is merely to introduce adult ways of thinking, which conflict with the child's own and eventually supplant them. ...Our own approach focuses on this interaction [of development and instruction].* (Vygotsky, 1962, p.117)

Thus, the focus moves away from age-related stages of development and towards the idea of the teacher as central in cognitive development. In consequence, the teacher can be seen as instrumental in helping the cognitive development of the child, whatever the age or stage of the child; and the need for different types of education, at primary and secondary level, becomes redundant.

Vygotsky also maintained that the development of language is essential in concept formation. This importance of language in concept formation was explored by Barnes et al (1969), who identified a 'language of secondary education' as a barrier to learning. This language was regarded as distinct from the subject specialist language, which was often encountered on transfer. This form of language was outside the linguistic experience of most eleven-year olds, and it was hypothesised that children who were unable to master this new language would have difficulty in learning, on transfer to secondary school. From the point of view of science education, there were therefore two barriers to be overcome on transfer to secondary school: the specialist vocabulary of science and the 'language of secondary education'. The need for common language was explored later by Edwards and Mercer (1987) who regarded education as a communicative process, and therefore gave prominence to the philosophies of Vygotsky and Bruner.

In Bruner's view children could build upon previous experiences and knowledge with the help of teachers. The role of the teacher was to provide a 'scaffolding' for the pupil, which linked their existing knowledge with new knowledge. Thus, ideas could be explored within a familiar context so that new meanings and concepts could be constructed. Two important aspects of scaffolding are <u>context</u> and <u>continuity</u>. The <u>context</u> is the shared understanding of the words used to describe mental phenomena; when the participants' conceptions of each other's mental views are incorrect or incomplete this shared context breaks down. Continuity here is a framework of shared understanding between children and teacher and is the foundation for future learning. Therefore, at transition from primary to secondary school there is a crucial requirement for a common understanding of roles and aims between the primary and secondary level teachers.

Edwards and Mercer also stress that discovery learning alone is insufficient for learning, unless scaffolding allows the process to be meaningful:

> *...talk between teachers and children helps build the scaffolding; children's activity, even 'discovery', in the absence of such a communicative framework may, in cognitive terms, lead nowhere.*
> (Edwards & Mercer, 1987, p.167).

This extract expresses clearly the difficulty for informed primary level teachers, who while relying upon the Plowden ideology of discovery learning, may fail to make explicit the purposes of the science learning. It also re-emphasises Ausubel's view that discovery learning alone will not lead to meaningful learning.

Thus, the use of Piagetian theory stressed the differences between primary and secondary schooling, and the ideas of Ausubel, Vygotsky and Bruner all have particular roles in reducing these differences. Meaningful learning at primary school requires the careful use of shared language and explanations, but progression in learning *on transfer* requires the continuity of that shared context, rather than the separation of the teacher's role from the child's development. Furthermore, since meaningful learning is dependent upon previous knowledge, transition should not imply the beginning of a completely separate educational stage.

A more recent approach in science education – the constructivist approach –also employs the above ideas. The constructivist approach to science teaching is defined in terms of how the learner is helped to interpret phenomena in terms of their previous experience and culture. For example:

> *The most important feature of an approach to science classes, which addresses the difficulty of changing ideas, is conversation. Science lessons which continually seek learners' ideas, which help to clarify them, and which provide an open and unthreatening environment for changing these ideas through conversation are classes in which learning science can be improved.* (Carr et al, 1994, p.158.)

In theory, this constructivist approach to science learning should provide the means to reduce the transition gap since it requires an approach involving more discussion and collaborative activities, and while such an approach might be used frequently in primary schools it has been less commonly found in secondary science lessons. However, in practice this approach has often been found difficult by primary school teachers because of the levels of knowledge and confidence it requires on the part of the teacher (Russell et al, 1994a). Lack of pedagogical knowledge may present difficulties in knowing what questions to ask, and in which ways to develop children's discussion of ideas. As Osborne and Freyberg (1985) put it,

> *Teachers who are themselves insecure in their knowledge of science can find the uncomplicated transmission of knowledge attractive* (quoted in Carr et al, 1994, p.148.).

The ASE recognised the problems in this type of science teaching, and stressed the need for initial teacher training which concentrated on the methodology of science teaching and which promoted confidence :

> *Courses should emphasise ... how best teachers with limited personal knowledge of science can stimulate and facilitate such a process.*
> (ASE 1981, p.35)

However, this issue of primary teachers' knowledge and confidence in science, continued to be problematic as the science curriculum developed, and it will be discussed further on pages 33-36.

The developing ideas of philosophers of science were also influential, in this debate, and it is relevant here to refer briefly to the ideas of Karl Popper and Thomas Kuhn. Before the 20th century, the dominant view of science was 'positivist', namely,

> *The idea that science has three separate stages: description, followed by induction of generalisations that then have to be tested against new observations of the same phenomena (or perhaps by an experiment) to check whether the generalisations hold true.* (Dunbar, 1995, p.18.)

This is still the view of many non-scientists today. However, in the 1930s Popper suggested that science proceeds by generating hypotheses and by then attempting to disprove these hypotheses, that is, by a process of falsification. Dunbar says this view of science was too dogmatic, indicating only what scientists ought to do; but in practice, what they actually do was better described by Kuhn (Dunbar, 1995). Kuhn suggested that scientists proceed by testing a theory rigorously over a period of time until eventually there is general acceptance of it among the scientific community. This theory then becomes 'normal science'-the paradigm. Eventually, this theory will begin to be falsified, and the amount of falsification will become so great that once again there will be what is called a 'paradigm shift'. This view of science has led some to take a relativist position, where the theories of science are seen merely as the product of the culture, and without external validity. However, in an alternative rationalist view, science proceeds by testing theories until they are found to be falsified, and then replaces old theories by a new ones, which will also be rigorously tested.

Within such philosophies is the potential for differences of opinion about the nature and status of science, and such differences may be exacerbated by the scientific understanding of the individual. Here, then, is another possible division between primary and secondary teachers; the difference in science understanding at these two levels may be linked with different views of the nature of science. If this were the case, then the gap between primary and secondary science would be not just in terms of teaching style and level of knowledge, but also in actual views of the nature of science.

Such ideas have certainly been influential in changing the methods of secondary teachers from the didactic to the more consensual, but it is possible that they have had a different effect upon primary level teachers. The relativistic ideas of Kuhn may be taken as a reason for discovery learning, as in the following quotation.

> *If pupils were to be trained for such an uncertain battlefield, it could be more important that they were armed with a foretaste of discovery than with an armoury of well-learnt theories which might be superseded tomorrow. (Solomon, 1994, p.14.)*

Piagetian theory was given a new franchise through the work of Shayer and Adey (1981). The Cognitive Acceleration Science Education (CASE) project was based on Piagetian levels of cognitive development, and was designed to bring forward the onset of formal operational thinking (Adey, Shayer & Yates 1989a). The scheme involved the deliberate development of cognitive conflict, and although there may be some element of assistance by the teacher, this was directed towards developing cognitive conflict rather than directly assisting the pupil in solving the problem (i.e. scaffolding). The first experimental results obtained by Adey et al (Adey, 1987; Adey et al, 1989b) indicated that <u>overall</u> the use of the

CASE scheme had a positive effect, the experimental group made gains (in terms of Piagetian levels) significantly greater than the control group. Later work suggests that children who have used the CASE scheme perform substantially better in Key Stage 3 tests than children who have not been exposed to the scheme, and that there are positive long-term effects on GCSE levels (Shayer, 1999). This work will be critically reviewed in Chapter 2.

It has been suggested that classroom context might have had an important influence on the CASE results. The CASE scheme encouraged small-group teaching, requiring children to be more autonomous, whereas whole-class lessons tended to lead to more formal, teacher-controlled activities (Leo & Galloway, 1996). Most effective teaching in the past relied heavily on a didactic approach where much of the time was spent on whole class teaching, but there has been a move to greater use of small group work over the years (Kyriacou, 1997). Cooper and McIntyre (1994) in a study of the perceptions of teachers' and pupils' perceptions of effective classroom learning, found that their sample of year seven pupils regarded the use of group work as particularly helpful to their learning. It enabled pupils to advance their thinking in ways that they could not achieve alone. Group work can be seen as offering both scaffolding (here provided by peers as well as by the teacher), and also opportunities to organise concepts into meaningful learning. Pupils expressed a strong preference for this teaching method, but the sample of teachers of these pupils (8 English teachers and 5 history teachers) did not see group work as distinctive, and tended to regard different methods as appropriate for different learning tasks. A variety of teaching approaches have long been used in primary classrooms, but the use of individualised or group work has tended to predominate, (see for example Bassey, 1978 and Gammage, 1986). The increase in the use of this approach at secondary level should again improve continuity of learning experience for children on transfer.

In summary, developments in psychology and philosophy over this period (1967-87) should have had the effect of reducing the differences between primary and secondary school science teaching approaches, and by 1988, when the National Curriculum was introduced, continuity in learning and teaching methods should already have improved. One function of the National Curriculum was to encourage curricular continuity from primary to secondary school, and in the next section, curricular changes leading to the establishment of a National Curriculum will be examined.

1.2.2 THE DEVELOPMENT OF THE SCIENCE CURRICULUM

Scientific teaching ought to be made a fundamental part of all primary teaching in the kingdom (Huxley, 1872).

Table 1-1: Twenty two years of science development

Year	Curriculum development
1967	Science 5-13 Project set up
1974	APU inaugurated by DES
1976	The Ruskin college speech – call for national standards and a core curriculum.
1977	The great debate – no national control of the curriculum but instead consultation
1978	HMI report on Primary Education – 'in science the work was weak overall.'
1979	HMI The secondary survey – broad and balanced science advocated
1979	ASE consultative document 'Alternatives for science education.'
1980	First APU report on science DES publishes 'A framework for the school curriculum' but states that there is 'no intention of seeking to change the existing pattern of responsibilities for the curriculum but emphasised that they had "an inescapable duty to satisfy themselves that the work of schools matches national needs."
1981	DES publishes 'The school curriculum' – guidance to the education service. A key issue is the recommendation that primary science should provide more effective science teaching. ASE policy statement: Education through Science
1982	DES green paper 'Science Education in Schools – all children should have a broad science education until the age of 16. Proposals concerning primary science.
1983	The school curriculum development committee is established and the schools council was to close in 1984
1984	Discussion paper: 5-16 curriculum issued
1985	DFE produces 'Science 5 to 16 a statement of policy' – all pupils in primary schools should be properly introduced to science.
1987	Science national Curriculum working group established
1988	First draft of the Science National Curriculum published (22 attainment targets)
1989	Science National Curriculum becomes law. All children have a legal entitlement to a science education. (17 attainment targets)

At the start of this period, that eloquent Victorian, T. H. Huxley's vision of science education for all primary children seemed close to realisation. Blackie, writing in 1967 reflected optimism about primary science:

> *Science is fashionable and for very good reasons, so that no excuse is required for including it in the curriculum. Geography and History, time-honoured school subjects though they are, are rather less secure…*
>
> (Blackie, 1967. P.100).

Pressure for a consideration of 'primary stage science education' had come with the formation of the ASE in 1963, and its subsequent general policy statement in 1965, entitled *School science and General education.* Science was being taught in many primary schools, the Nuffield Junior School Project (NJSP) had produced science books for teachers' use, and another large-scale science project (commissioned by the Schools Council) was about to begin (Plowden, 1967).

The Science 5-13 project, which developed out of the NJSP, and was funded chiefly by the Schools Council, was begun in 1967. Overall, the project aimed to provide help for teachers in teaching science to children in the 5 to 13 age range (Harlen,1975). The project lasted for seven years, producing 25 books with much guidance for teachers; and it was praised by the Schools Council for its work in curriculum development and for *'the first major attempt to establish some continuity of learning across the upper primary and lower secondary boundary.'* (Ross, Razzell and Badcock,1975). Despite the availability of these excellent materials, when the Schools Council visited schools, between 1968 and 1972, they found that some schools included very little science teaching in the curriculum (ibid, 1975). They suggested that non-specialist teachers at junior level needed more encouragement and help in delivering a science curriculum. It has been suggested that the NSJP also had limited influence for similar reasons: because of *'teachers' lack of confidence'* and *'the paucity of their own scientific knowledge'*, (Boyd, 1984). These issues of teacher confidence and scientific knowledge re-emerge as a source of concern throughout this period of development in the primary science curriculum.

The following years saw the publication of major reports detailing science teaching in primary schools. The HMI survey of primary schools in England took place between 1975 and 1977, (HMI, 1978), and the Assessment and Performance Unit reports on Science in Schools began in 1980, the first one being issued in 1981, (Harlen,1981). The HMI survey *Primary Education in England* (1978) found that little science was being taught in primary schools. In about 20% of the 542 schools surveyed, there was no evidence of any science work. Where science was included, the *'work in observational and experimental science was less well matched to children's capabilities than work in any other area of the curriculum'* (HMI, 1978). In commenting upon this state of affairs, the Report observed that,

> *The most severe obstacle to the improvement of science in the primary school is that many existing teachers lack a working knowledge of elementary science appropriate to children of this age. This results in some teachers being so short of confidence in their own abilities that they make no attempt to include science in the curriculum.* (HMI, 1978, p. 58).

Support for teachers was recommended: in-service training for teachers with responsibility for science, better resourcing of school science and greater attention to the role of initial teacher training.

One result of the HMI survey was to bring the issue of subject specialism in primary schools to the fore. Where the Plowden Report mentioned the role of subject co-ordinators it was in the context of advice and support for class teachers. The suggestion that individual teachers in primary schools might take responsibility for one particular area of expertise and help their colleagues, even to the extent of teaching children from outside their own class was new.

As Thornton (1998) has observed,

> *This was the first endorsement of more subject-specialist teaching in primary schools, reiterated frequently in subsequent DES, HMI and Select Committee Reports. It represented a substantial challenge to the orthodoxy of generalist class-teaching.*

At the time, this suggestion was welcomed, but with the note that very small schools might have difficulty with providing the necessary expertise across the whole curriculum. (Thomas, 1980).

The APU reports between 1980 and 1985 found that there had been an increase in the amount of time spent on science, but generally the proportion of time allocated was still less than the10% regarded as appropriate (HMI, 1985). Despite the earlier recommendations of HMI, the proportion of teachers receiving in-service training in science remained very small (9% of all teachers in England & Wales). Priorities in terms of science–based activities remained unchanged over the five years, with observation skills, enjoyment of science activities and development of a questioning attitude topping the list. Understanding basic concepts, correct use of simple equipment and ability to plan experiments had remained at the bottom (Harlen, 1988). Children's performance in the APU science tests over this period appeared static: overall they found no change, and there were no apparent links between school characteristics, such as amount of time spent on science, and performance. However, there was some evidence to indicate that children performed better where teachers had some science training (Harlen, 1981). There were clear indications that socio-economic factors and gender were relevant to performance, favouring the more affluent catchment areas and boys (for application of science concepts) (Johnson, 1988).

After the national primary survey (1978), there was a slow but steady increase in the amount of science taught in primary schools, but teachers' confidence and knowledge of science remained an issue (HMI, 1989). Twenty years on from the optimism for primary science expressed in the Plowden Report, children moving to secondary school were still thought to perceive a discontinuity in their science education on transfer (Hadden, 1981; Craig, 1987).

Meanwhile, secondary science had also been the subject of scrutiny. Between 1975 and 1978, HMI surveyed 10% of all maintained secondary schools in England. Of major concern were teaching methods and the lack of opportunity for many children to study science beyond the age of 14 (HMI, 1979).

HMI were critical of teaching methods, finding too much didactic teaching and note taking and too little opportunity for children to develop their own thinking. It was acknowledged that practical work was being done, but a 'more problem-solving ' approach was advocated. There was concern about lack of teacher qualification: 16% of those teaching physics had no qualification in physics, and 5% of science teachers had no science qualification at all. There was a recommendation that teacher training for specialist scientists should include some training in the *full range* of sciences, and that more physics students should be recruited. In these recommendations can be seen a reflection of developments at primary level, and a movement towards narrowing the gap which existed between primary and secondary science.

There was also concern about the number of pupils *not* doing science, particularly after the age of 14. HMI advocated a broad and balanced science course up to the age of 16-plus for all pupils. Particular concerns were expressed about girls, for the survey had revealed that tradition still prevailed with more girls opting for biology and more boys opting for physics.

> *By not studying the physical sciences beyond a very elementary level, girls are denying themselves skills and knowledge in important areas of the curriculum and are cutting themselves off from many career opportunities in science and engineering. (HMI, 1979, p199)*

This was a period during which *'a level of agreement about frameworks for science education'* was reached (Nellist, 1989). The question of what should be included in the science curriculum centred on the 'process – content' debate. At secondary level, concerns were expressed about the 'sheer amount' of content, and the unresolved problem of fitting in the desirable amount of practical work whilst maintaining examination standards (Ross, Razzell and Badcock,1975). Nevertheless, there was an increased emphasis on skills rather than on specific subject matter in secondary science as attested to by the publication of schemes of work such as 'Warwick Process Science' (Screen, 1988) and 'Science in Process' (ILEA, 1988). As mentioned above, the APU had found that primary teachers were concerned to develop skills, enjoyment and questioning attitudes rather than an understanding of basic concepts, but the need for a balance between process skills and content at primary level was recognised (Harlen, 1978). These developments tended to bring the primary and secondary sectors a little closer together.

Through the work of the APU it became clear that process and content/concept were inextricably linked in school science. They identified the requirement for both the generalist process work and the specialist knowledge base. As Black and Russell (1988) put it,

> *The data, in showing how performance falls rapidly when more precise and developed levels of skills are explored, and in demonstrating how inextricably linked process and content may be, do not suggest that all will be plain sailing in the process curriculum* (Op Cit, p.121).

Political and economic pressures operating during this time caused an increase in the government's concentration upon the science curriculum, culminating in the introduction of a 5-16 National Curriculum for Science. First, there was the so-called 'Swing from Science': the shortage of boys and girls going on to study science and technology in higher education, which was first brought to prominence by the Dainton Report (1968). It had been hoped that this swing from science would be only temporary, but government statistics showed plainly that the proportion of those choosing to study science beyond 16 continued to decline, (see for example DFE, 1994). International comparisons of achievement, such as the IEA tests in 1970-71 and 1983-84, suggested that England was achieving less well than many other countries in science at every level (Keeves, 1992).

The 'Black Papers' – critical reports on teaching methods and standards following the Plowden and Dainton Reports - were another source of pressure. The so-called Black Papers were a series of publications, beginning in 1969, in which concerns were expressed about the use of progressive methods and standards in maths and science.

> *By the mid 1970s, the suggestively ambiguous central concepts of the right ('standards') and their imprecise but sweeping demands (for more 'control') seemed to be ubiquitous and virtually uncontested.* (Education Group, Centre for Contemporary Cultural Studies, 1981, p.200.)

Against this background of strongly critical comment about education, the then Prime Minister, James Callaghan, made his famous Ruskin College speech (1976), which many regard as a watershed for current attitudes to schools. He called for a public airing of concerns about educational standards, and initiated 'the great debate', also pressing for national standards and a core curriculum. 'The great debate' in 1977 addressed four areas: the school curriculum 5-16; the assessment of standards; the education and training of teachers; and school and working life. However, the concerns about standards were evident in the commissioning of the APU in that year, to develop test materials for monitoring pupil performance in mathematics, language and science (DES, 1977).

HM Inspectorate's Report, *A view of the Curriculum*, based on their recent surveys of primary and secondary schools, initiated consultation on policies for the curriculum (DES, 1980). This was closely followed by *The school curriculum* which recommended the provision of more effective primary science teaching and, for secondary science, a broad curriculum up to 16 (DES, 1981). During the same period the DES continued to press for improvements in the transition process, and expressed concern about the break in continuity and progression at transition. A consultative paper in 1982, *Science Education in Schools*, set out the objective of a broad science education for all children up to the age of 16. The School Curriculum Development Committee was established in 1983 as the successor to the Schools Council, to promote curriculum development, and discussion papers on a 5-16 curriculum were published in 1984. In 1985 the White Paper *Science 5-16: A statement of policy,* was published, in which it was stated that,

- Science should have a place in the education of all pupils of compulsory school age, whether or not they are likely to go on to follow a career in science or technology.
- All pupils in primary schools should be properly introduced to science.
- Throughout the secondary years each pupil should have a programme of study, which is broad and balanced.

Pressure for suitable continuity arrangements in view of the increasing amount of science taught in primary schools (DES, 1985) led to science becoming a "core" subject in the National Curriculum and for the first time a compulsory subject at primary level.

These gradual changes had moved science education from a subject specialism at secondary school to a part of every child's educational entitlement from the age of 5 years. However, teacher training had lagged behind. For many primary school teachers the introduction of the science National Curriculum made new demands about which, initially, they did not feel at all confident (Wright, 1990; Sorsby and Watson, 1993).

In 1978 HMI had been clear that science knowledge among primary teachers was weak, and had recommended greater attention to the role of initial teacher training. The ASE had also stressed the need for initial teacher training to promote confidence in science teaching. However, changes in teacher training were slow in coming, and it was not until the late 1990s that government intervention made primary science a compulsory element in all initial primary teacher-training courses (DfEE, 1998), and ensured that all entrants had a science qualification[1]. The issue of primary teachers' confidence in science teaching is a subject of some considerable research, and will be returned to in the next chapter.

1.2.3 Developments in Attitude Theory

As mentioned in Section 1.1.2, attitudes were originally regarded as important because they were thought to affect behaviour, and the relationship between attitude and behaviour was a subject of much research in the years following the

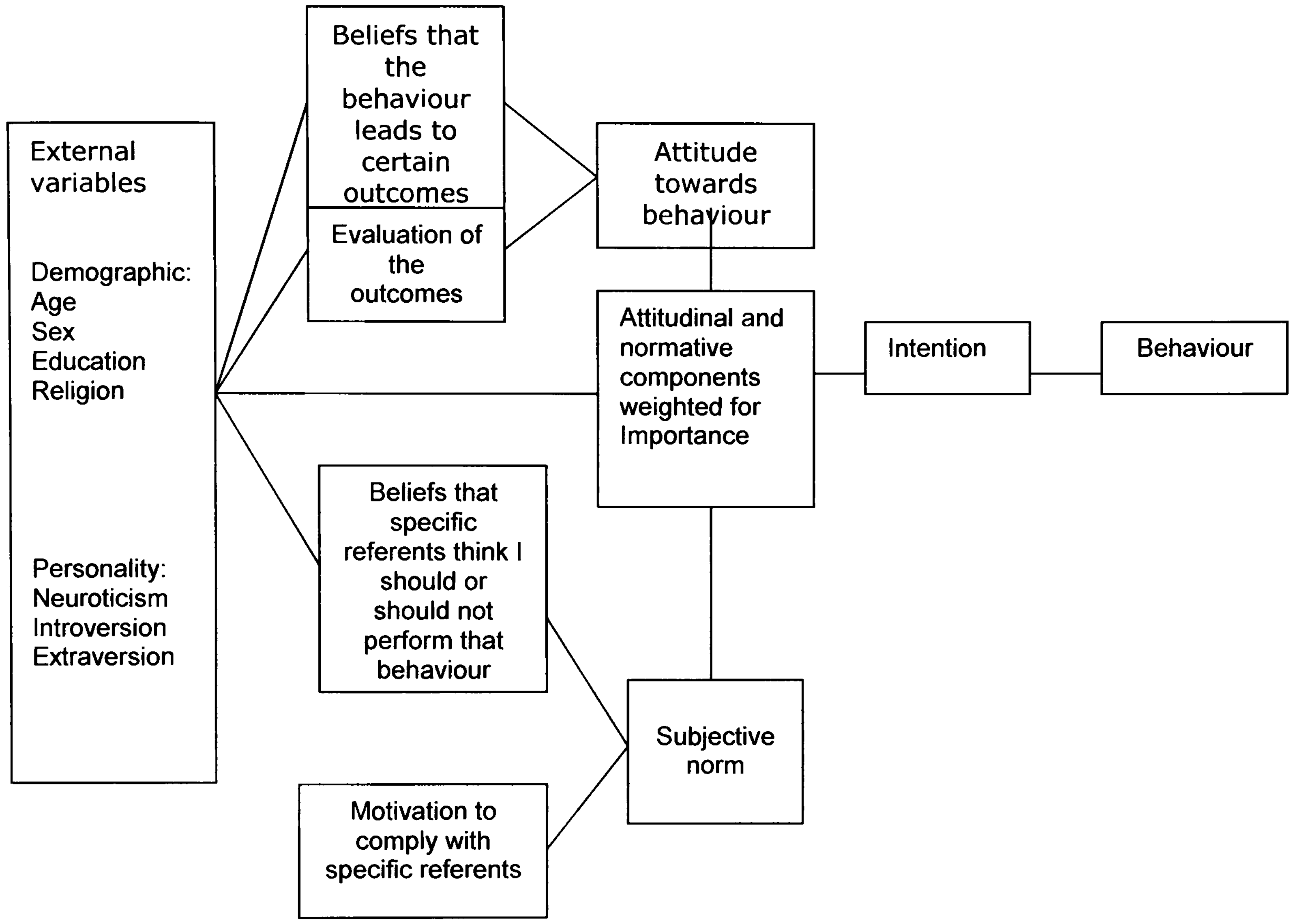
[1] Since 1998 entrants to primary teacher training have been required to have achieved a minimum of GCSE grade C or its equivalent in science.

work of Hovland, Janis and Kelley (1953), but the outcomes of this research were not promising. By the late 1960s there was general disillusionment about the relationship between attitude and behaviour, and it was suggested that attitude was probably unrelated (or only slightly related) to behaviour (Petty & Cacioppo, 1996).

However, earlier research was brought together around what has been called a 'cognitive approach' to the study of attitude and persuasion (Eiser, 1980). In the light of research showing low and typically non-significant correlations between attitude and behaviour, Greenwald et al (1968), proposed that it was not the message itself but the individual's response to the message that determined the level of persuasion or resistance. He introduced the term 'cognitive response' to describe this process. The basic assumption was that individuals processed the information in any message and that their attitude was based on their response to thinking about the message and not to the message itself (Petty, 1995).

Ajzen and Fishbein (1975) extended this idea of the individual as a message processor, and formulated theories suggesting that, under certain circumstances it would be possible to predict behaviour. The basic assumption of their theories is that that individuals think about the consequences of their actions and make deliberate decisions to achieve some outcomes and avoid others. Ajzen and Fishbein (1975) combined various aspects of earlier theory, suggesting that an individual's attitude towards a behaviour and the effects of social learning would both have an affect on the behavioural outcome. The elements of this *theory of reasoned action* are illustrated in Figure 1-4 overleaf.

Figure 1-4: The theory of reasoned action



Fishbein and Ajzen's *theory of reasoned action* (1975) is a theory of how attitudes predict planned, deliberate behaviour. According to their theory, an individual's behaviour can be predicted if two things are known: the person's specific attitudes and his or her 'subjective norms' toward the behaviour. Attitude refers to the person's positive or negative feelings about engaging in the behaviour, and subjective norms refers to the person's perceptions of the social pressures to perform or not perform the behaviour. Generally people will perform behaviours that they value highly and that are popular with others, and will refrain from behaviours that they do not regard favourably and that are unpopular with others.

Accumulated research has provided rather consistent support for the notion that specific behavioural intentions can be predicted from attitudes and subjective norms as specified in the theory of reasoned action. (Petty and Cacioppo, 1996).

This model has been shown to be useful for situations where individuals have time and inclination to think about possible behaviour. However, it has limited application because within this theory behaviour is assumed to be always rational. The idea that human beings always act in a rational way has been questioned and the results of experimental research by Fazio and others, which are discussed below, indicate that this assumption may not always be true. Furthermore, to suggest that attitude precedes behaviour is to ignore research by Bem and Festinger indicating that behaviour drives attitude (Eagley and Chaiken, 1993). Indeed it is likely that behaviour and attitudes are reciprocal rather than unidirectional (Ausubel, 1978; Petty, 1995).

Bem (1972) explained consistency using the theory of self-perception. According to Bem much of our behaviour is not a product of thinking about internal feelings and attitudes prior to acting. Instead the opposite often happens, and we infer our own attitudes in the same way as we infer other people's attitudes, through looking at our own behaviour. Thus, our attitude results from our behaviour, and as Zimbardo & Lieppe (1991) put it,

> *When we are directly asked our opinion about something or when we expect to encounter the object directly in the near future, this is the time when we turn to perceptions of our behaviour to discover what we believe about an issue. (Op. cit. p.100)*

During the early 80s Fazio, Zanna and others studied the impact of direct experience on attitude-behaviour relations and observed that attitudes based on direct experience are more predictive of behaviour. They came to believe that the underlying reason for this is that they are more accessible from memory. Eagly and Chaiken describe this as follows,

> *...attitudes based on direct experience are more easily retrieved from memory than those not based on direct experience. More specifically, the speed with which attitudes are accessed, ... is regarded as consequential in relation to attitude-relevant behaviour. Attitudes that are more accessible (i.e., activated quickly) are presumed to be more powerful determinants of behaviour than attitudes that are less accessible (i.e., activated more slowly) because they are more likely to be activated upon exposure to the attitude object or other relevant cues. (Eagly and Chaikin, 1993, p.195.)*

Later work by Fazio and colleagues, published in 1986, developed the view that attitudes that are highly accessible will be automatically activated in the presence of the attitude object, this is often referred to as 'priming'.

These theories made use of the idea that attitudes could be accessed through schemas. Schemas are regarded as,

> *Cognitive structures of organised prior knowledge, abstracted from experience with specific instances.* (Fiske & Linville, 1980, p.543.).

The measurement of attitudes developed considerably after the early papers by Thurstone (1928) and Likert (1932). Selltiz et al (1981) placed current methods into five main categories: inferences from self-reports, observation of overt behaviour, reaction to partially structured material, performance on objective tasks and physiological observations. These methods of measurement will be described briefly below.

Measures in which inferences are drawn from self-reports, for example questionnaires, using Likert or Thurstone scaling, were by far the most commonly used. They relied on the assumption that there was a relationship between attitude and expression, and that attitude preceded behaviour or that attitude and behaviour were reciprocal.

Since attitudes might be situation specific they might be best examined ‘in situ’, and this was done by observation of overt behaviour. Since subjects need not be aware that they are being ‘measured’ this method should not be affected by experimental bias. However, attitudes were inferred on the assumption that attitude and behaviour were consistently linked and, as stated earlier, the link between attitude and behaviour was not entirely consistent and therefore such measures were not frequently used.

Indirect measures in which inferences were drawn from the individual’s reaction to partially structured stimuli, for example projective tests, or their performance on objective tasks were seen as a way of overcoming some of the response barriers associated with direct questioning (Oppenheim, 1992). However, such tests made assumptions about the relationship between attitude and corresponding behaviour and doubts about the validity of that assumption were expressed (Catterall & Ibbotson, 2000).

Physiological measurements such as the use of lie detectors were regarded as being of doubtful value and were not regarded as appropriate or ethical in educational research (Oppenheim, 1992; Eagly & Chaikin, 1993).
Thus, during this period (1967-1987), although a wide variety of techniques were available for measuring attitude, few were in common use, and the attitude questionnaire was by far the most widely used. More recently there has been a renewed interest in the use of projective techniques and an increased use of interview and observation; however, attitude questionnaires remain in common use.

1.3 The years of direction: 1988 – 1998

1.3.1 After the National Curriculum

The culmination of the many changes and concerns outlined in Section 1.2 came in 1988 with the Education Reform Act, and the introduction of the National Curriculum into schools between 1989 and 1992. The National Curriculum, it was claimed, would,

> *...help children's progression within and between primary and secondary education ... and will help to secure the continuity and coherence which is too often lacking in what they are taught.* (DES, 1987, p.4.)

Despite the above claim, it would appear from recent reports that the problems of continuity and progression on transfer may not have been solved, and that there may also be new problems emerging as a result of the 1988 Act. Two examples, from two very different LEAs, Suffolk and Lewisham (South London), demonstrate that the problems outlined in Section 1.2 seem to be still much in evidence (Table 1-2).

Table 1-2: Two examples of the problems of transition

Suffolk (1997)	Lewisham (1997)
Little regard to pupils' prior experiences and attainment	Too little knowledge [is assumed] on the part of Year 7 children, rather than too much
Little use is made of the information that is transferred between schools	Little use made of primary records
Belief in a 'fresh start' approach	The 'blank sheet syndrome' was common

Sources: derived from Yardley, 1997 & Suffolk LEA, 1999).

A large-scale survey by the NFER in 1995 indicated that these issues are not restricted to only a few LEAs (Lee et al, 1995). This survey, using questionnaires and interviews with a full range of types of LEAs across England and Wales can be regarded as representative of general practice. Lee et al concluded that there was a priority need for *'establishing good transfer of information'.* Differences in practice and perception were highlighted, and collaboration between teachers in the two sectors was recommended by these authors,

> *There is still some lack of continuity between the primary learning focus and the secondary focus on subject knowledge, and there is perhaps a place for collaboration between primary and secondary staff on core/learning/thinking skills, in order to bridge the differences and get to the roots of progression in children's learning.* (Lee, Harris & Dickson, 1995, p.93.).

In the same year The House of Commons Education Committee (1995) presented a report on the particular problems of continuity and progression in science and technology between Key Stages 2 and 3. They found that,

> *The problem of discontinuity is particularly stark at Key Stages 2 and 3, when pupils generally transfer from primary to secondary school. Here, we found evidence of both work and assessment routinely being repeated, leading to children becoming bored and demotivated. (Op.cit. p. xv, Vol. I)*

They emphasised that this applied *to ...all of the Curriculum to a greater or lesser degree.*

By 1995, all children in their first year at secondary school had been exposed to National Curriculum science since the beginning of their primary education. This was the year in which the planned National Curriculum programmes of study were to come to fruition, and the first reported assessments would take place (DES, 1989).

So even after seven years of a National Curriculum for science, it would appear from all of the above that, not only had the 1988 Education Reform Act not solved the earlier problems of transition, but new concerns might also be emerging. These concerns related to three main areas: new difficulties for continuity and liaison strategies between the primary and secondary sectors, the effects of Key Stage testing, and teacher training and in-service training in science.

To take the first of these concerns, the promised improvement in continuity had not materialised. The greatly increased emphasis on parental choice and the element of competition between schools (another aspect of the 1988 Education Reform Act) made liaison between schools *more* difficult to achieve. Before the Education Reform Act, it was usual for a primary school to regard itself as a feeder school for only one or two secondary schools; but since 1988, children from one primary school might have a choice of at least six different secondary schools. This change increased organisational and time-management problems for primary school staff who, under other circumstances, would wish to collaborate with secondary school staff. Similarly, secondary schools, now taking pupils from a much wider geographical area and a much larger number of primary schools, had a more difficult task in ensuring good liaison.

Increased parental choice and the introduction of Grant Maintained schools made mitigation of these problems difficult. The rationalisation of the transfer procedure for all the schools in a particular locality was often more problematic as a result of parental choice (Schagen & Kerr, 1999). It was suggested that Local Education Authorities should encourage and assist the formation of clusters of schools working together, to overcome the problems highlighted (Lee, Harris & Dickson, 1995). This, however, did not fully take into account the particular situation of opted-out schools; for example, at the time of the present study of

Essex schools there was a very high proportion of grant-maintained schools at both primary and secondary levels[1]; and the LEA was not directly involved.

Secondary schools have developed a variety of strategies to deal with such difficulties over continuity and liaison, and generally, they are similar to those recommended by SCAA (1996). The development of liaison strategies with a specific focus on curriculum and/or assessment, and good transfer of records of achievement have been emphasised. But, in order that the transfer of information could be effective, liaison with primary schools needs to be an essential feature of any strategy. Collaboration between the two phases should be regarded as a fundamental requirement.

However, although most secondary schools do try to use such strategies, there are still problems. Curricular progression is apparently hindered by the failure of many schools to pass on records of National Curriculum levels, and secondary schools feel that the scores would be more useful than the National Curriculum levels (Schagen and Kerr, 1997). An emphasis on differentiation relies on the effective use of assessments made at the primary school, the secondary school or at both schools. As a SCAA report put it,

> *Evidence, including that from OFSTED, continues to show that, in some schools, pupils are given work that is pitched at an inappropriate level... in secondary school.* (SCAA, 1996, p. 10)

Furthermore, as indicated in Table 1-2 (page 46), it is suggested that many secondary teachers still do not view the educational process as continuous and that another strategy, *not* recommended by SCAA, is used, namely, the 'clean slate' approach. The 'clean slate' approach assumes that children need to begin

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[1] In Essex, three out of four secondary schools and one in ten primaries opted out in the 1990s.

afresh on science after transfer. One interpretation of this approach is that secondary science teachers lack confidence both in the science teaching that has gone before, and in the content of the transfer information that has preceded the child to secondary school. This view has been eloquently described by one primary head-teacher, clearly he felt rather strongly about the issue,

> *The child goes into the secondary school as a blank sheet. They don't bother to look at the primary records. That's deliberate – they don't want to give a dog a bad name – and what we have to say isn't valued anyway. Then there's the curriculum. They assume the child knows next to nothing – blank sheet again, you see – and so they spend the first year repeating work we have already done with them. No wonder the poor little blighters are often bored out of their minds and start playing up.* (Yardley,1997, para.6.2)

Recent research by the National Foundation for Educational Research (Schagen & Kerr, 1999) suggests that many schools do still use the 'clean slate' approach and rely on their position as subject specialists. Their reported arguments for this position relate to the lack of trust in primary schools' ability to cover the work, the lack of a skills base in primary schools, and the lack of primary subject specialists in science. Secondary science teachers often view year 7 as children's *first year of science*.

Curriculum continuity has consistently been recognised as being dependent upon good primary-secondary liaison. But ultimately, differentiation of curriculum material is vital for progression; this demands good transfer of assessment information and the appropriate use of this information to provide individual learning programmes for the children concerned. The National Curriculum Levels of Achievement often have not met the needs of the teachers in the transfer schools, and their use appears to have slowed down attempts to simplify and rationalise the transfer of records (Lee, Harris & Dickson, 1995). Furthermore, some secondary schools "did not trust" the information provided by the primary schools, and hence the records were less likely to be effectively used (Russell et al, 1994b; Education Committee, House of Commons, 1995).

The above-mentioned problems concerning assessment brings us to the second new concern, referred to on page 48, which is related to Key Stage testing. The introduction of these tests may have exacerbated the break in continuity on transfer for three reasons. Firstly, there is a difference between children's Key Stage 2 test results and their performance the following year at secondary school. As a result of the Key Stage 2 assessments, teachers at secondary schools have expectations about the levels of attainment of the new intake of children. However, there is an apparent regression in achievement on transfer (for example, Sainsbury, Whetton, Mason & Schagen, 1998; DfEE/HMI, 1999; Doyle, 1999; OFSTED, 2000). The effects of this 'fall-back' are as follows: teachers at secondary school perceive children doing less well than expected and therefore set them work at lower levels than they were capable of in year 6 – thus preventing effective progression. Doyle (1999) suggests that the 'progress dip' on transfer[1] may be fuelling the mistrust between sectors, saying

> *...it is not surprising that teachers re-assess the children they receive into year 7 at a lower level than the key stage 2 tests, and consequently set the children work at a lower level than* [they] *had been capable of in Year 6 (Doyle, 1999, p.7).*

This leads to the secondary teachers' confidence in both the testing procedure and the ability of primary teachers to assess the children's levels correctly being reduced. Lack of trust by secondary teachers in the assessments

[1] Recent research indicates that the 'progress dip' identified by Nisbet and Entwistle (1969) and confirmed by Galton and Willcocks (1983) persists despite the 5-16 curriculum (Sainsbury, Whetton, Mason & Schagen, 1998; Doyle, 1999;). There is also evidence that the same effect occurs in the USA (Alspaugh, 1998).

may prevent the transfer information from being used (McCallum, 1996; Ellis, 1999; Schagen & Kerr, 1999; Suffolk County Council, 1999).

Secondly, there are concerns that the Key Stage tests might be causing an interruption in progression at primary level. There are indications that an increasing number of schools now regularly spend time revising during the middle term of the last year of primary education, in preparation for the tests (Hofkins, 1995; Ellis, 1999). After the tests there is a period of time before the end of the primary school year which some perceive as a gap between Key Stages (Zeneca Pharmaceuticals, 1997; Ellis, 1999). There is evidence to suggest that expectations in Year 6 diminish after the tests, as the Report by Suffolk Education Department (1997) indicates in this extract,

> *The programme of study is completed prior to the tests and a good deal of uncertainty exists as to what should happen in the rest of the term. This lack of direction can lead to some undemanding work being presented to pupils at the end of Year 6.* (Op. cit. Annex C, p.4.)

Could this be a new aspect of curricular discontinuity?

Finally, there are concerns that teachers are now 'teaching to the tests' and, that since Science 1 (investigative work) is not tested, this effectively reduces the science teaching to the transmission of content (Clarke, 1996).

The third emerging difficulty referred to on page 48, is related to teacher training and in-service training in science. As a direct result of the introduction of the National Curriculum, there were increasing demands for more specialist teaching within primary schools. It was suggested that a greater degree of specialist teaching would be appropriate in the final years of primary school (OFSTED, 1997). This demand for greater specialist knowledge, combined with continuing concern over primary teachers' science knowledge, increased the need for good quality provision of science teacher training and science in-service training. However, as mentioned above, science was not made a compulsory part of teacher training until 1998, and it will be recalled from Section 1.2, that concerns have been expressed over primary teachers' level of science knowledge for many years. Teachers' science subject knowledge and confidence have been areas of considerable research work, which will be examined in the next chapter.

1.3.2 FURTHER DEVELOPMENTS IN ATTITUDE THEORY

It will be recalled from Section 1.2 that early theories dealt with the effects of persuasion on attitudes, and the spontaneous changes brought about through the desire for consistency and/or social learning. However, attitude theories formulated during the 60s and 70s, tended to focus on specific issues and were more limited in their range; there was a particular focus on the relationships between attitude and behaviour. The more recent theories of attitude change have achieved greater breadth and attempt to draw together earlier theories into a coherent whole.

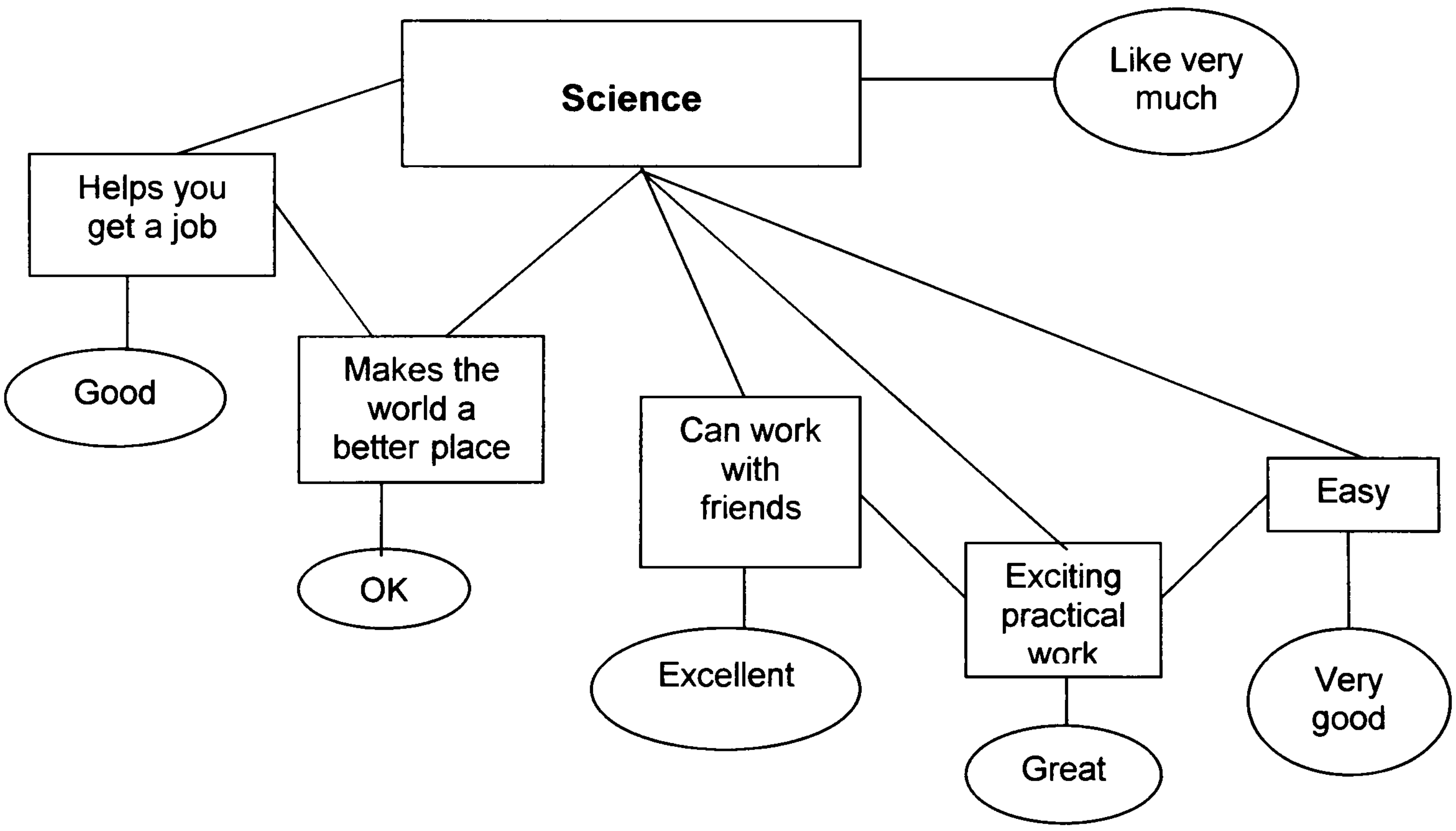
As discussed in Section 1.2, attitudes and associated information are generally believed to exist as attitude structures or schema. A current view takes this idea further, and suggests that attitude structures depend on an associative network model of memory, which allows rapid accessibility to a wide range of attitudes. The importance of such attitude structures have been described by Petty (1995) as follows,

> *... this means that if you ask people about one attitude, they will be able to give you their attitude about a related issue faster than an unrelated issue....Perhaps the most important implication of viewing attitudes as integral structures is that if you modify some particular aspect of the attitude*

> *....this will likely lead to some change in the overall evaluation of the object (i.e., the attitude) itself, though it might take some time and thought for the change to occur.* (Op. cit., p.200).

For example, in Figure 1-5, the individual is shown as having a favourable attitude towards science. This attitude can be retrieved directly from memory or can be constructed based on some subset of the various attributes the person associates with science. If the individual finds, say, that practical work is not exciting or that science is not easy then eventually there would be a change in the overall attitude to science.

Figure 1-5: Attitude structure.



(Source: derived from Petty, 1995, p.201)

In Section 1.2 it was noted that Fazio and colleagues held that most of the time decisions are not based on rational thought but on spontaneous processing of available attitudes. The network model described above implies that there may be a variety of accessible attitudes, which could be involved in such spontaneous processing.

From his earlier theories Fazio developed the MODE model (1990). This theory suggests that reasoned, systematic thinking is likely to operate only when the people have sufficient motivation and opportunity. At other times the attitude will be spontaneous and not based on a rational process. This model illustrates perhaps the most fundamental difference between the more recent and earlier theories; the earlier theories assumed a sequential route, whereas more recent theories assume that parallel routes could be involved.

The Elaboration Likelihood Model (ELM) (Petty & Cacioppo, 1996) and the Heuristic Systematic Model (HSM) (Chaiken et al, 1989), are two examples of dual processing approaches. Dual processing models visualise attitude processing occurring by two parallel routes, which depend upon the individual mode of thinking. Such models assume that individuals are motivated to hold valid or correct attitudes, but that they are not always sufficiently motivated to engage fully in processing the available information. The basic idea within the ELM is that persuasion hinges on whether the likelihood of relevant thinking is high or low. In order for attitude change to occur, an individual must be motivated to think about the message arguments. Only then can the following sequence of steps occur after being exposed to a persuasive communication:

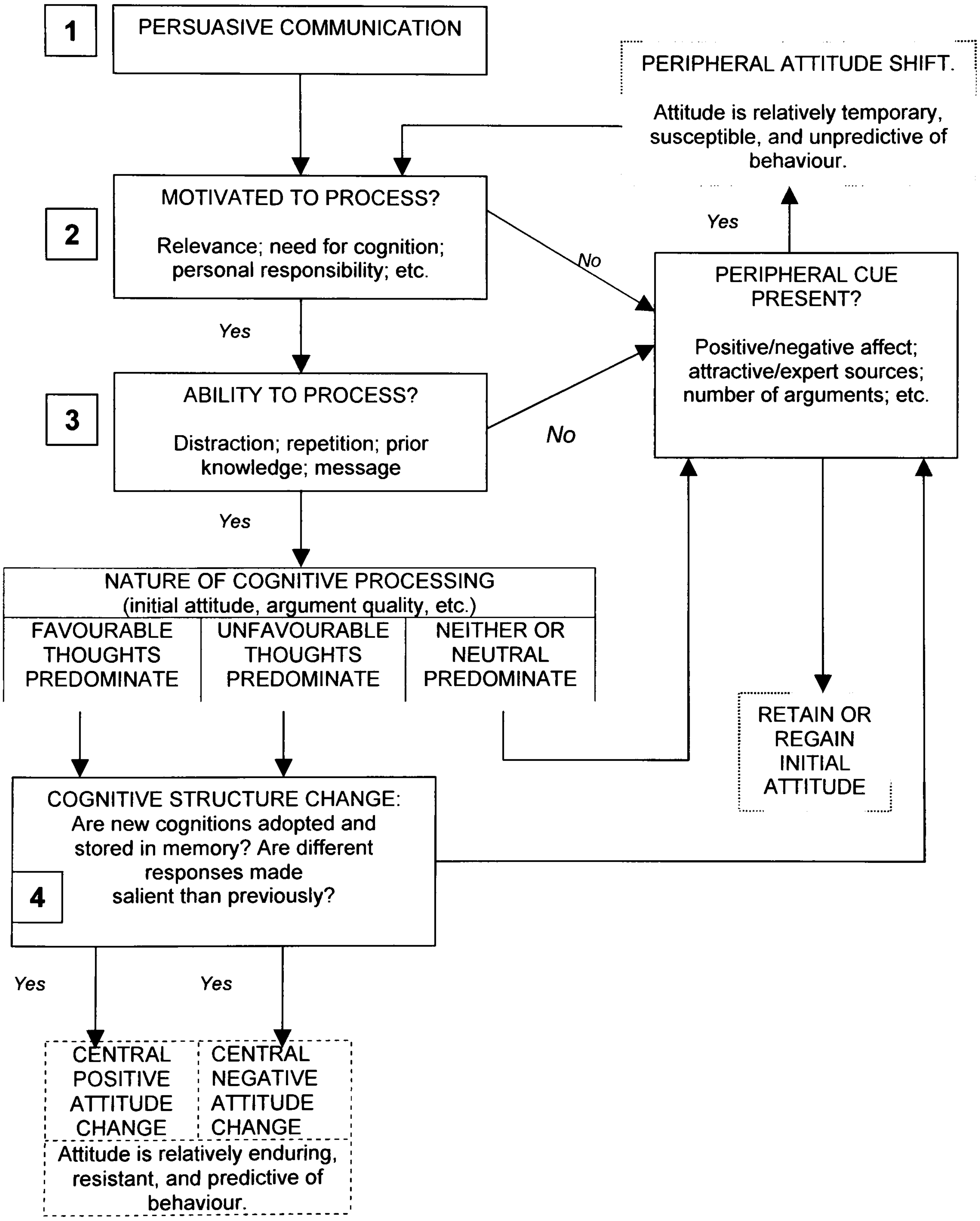
1. Attention to the message
2. Understanding of message content
3. Evaluation of the message
4. A change of attitude.

The ELM (Petty & Cacioppo, 1996) is represented in a simplified diagram in Figure 1-6 on the following page. In this model, central processing will occur only if the individual is both:

1. Motivated (cares enough about a topic to pay attention to it),
2. Able (is able to follow the argument).

Distractions reduce the chances of persuading even a motivated individual.

Figure 1-6: A simplified representation of the elaboration –likelihood model (ELM)



Individuals who engage in central processing think about the issues, and pay attention to the arguments presented. But even after some central processing, individuals may resort to peripheral processing at stage 3 if the information contained in the message does not produce a strong evaluation. At this stage the type of processing depends upon:

- Prior Attitude - if individuals already have strongly held attitudes, the arguments for a different view won't change them.
- Argument Strength – once stage 3 has been reached individuals usually shift towards the speaker's view, if the speaker's arguments are strong. But, if they are weak, individuals move further away from the speaker's position.

Attitude changes that occur via the central processing route are likely to last.
A weakness of the ELM as a theory was that it failed to explain why individuals would use peripheral processing rather than central processing. However, the HSM explains that situational and personality variables affect the mode of thinking that an individual will employ, and defines two modes of thought: systematic and heuristic. Individuals in systematic mode make an effort to think carefully, in contrast individuals in Heuristc mode do not think carefully about the arguments involved. Systematic thinking is “turned on” by relevance and comprehension. If a situation has little relevance or is difficult to understand then the individual is likely to use the Heuristic mode of thinking. Individual personality characteristics also affect modes of thought. Self-monitoring, the tendency to adjust one's behaviour to fit the situation, awareness of one's effects on others, and the ability to regulate one's non-verbal cues and behaviours to influence

others' impressions may be high or low. (Eagly & Chaiken, 1993).High self-monitors with a strong need for understanding, typically think carefully about things most of the time, in contrast low self-monitors have a low need for understanding and typically think as little as possible about a situation.

In Heuristic mode relatively simple 'rules of thumb' are used for making decisions. Such rules may include 'experts usually have valid arguments', or 'people like me are usually correct'. The net result is that the message *context* is given priority over the message *content*. Peripheral cues change a listener's opinion without relying on any active thinking about the issue. For example, a school pupil may base their attitude to school science on:

- Source credibility – 'my teacher is a science specialist'
- Source likability – 'my teacher seems nice',
- Pleasant setting – 'we work in laboratories, and do lots of practicals'

Changes in attitude on the Peripheral Route are not likely to last.

The persistence of attitudes has been linked to the amount of central processing and first-hand experience of the attitudinal object (Eagly & Chaikin, 1993; Petty, 1995), and the more people change as a result of processing the arguments the more they will resist any further change of attitude (Petty, 1995). An important implication of the ELM and HSM is that effectiveness is dependent on the personal relevance.

It was noted in Section 1.2 that although attitude questionnaires remain in common use, there appears to be a renewed interest in the use of projective techniques (Catterall & Ibbotson, 2000), and in interviews and observation. An examination of standard texts on attitudes reveals that when discussing attitude measurement these texts focused mainly on the use of attitude questionnaires (Zimbardo and Leippe,1991; Oppenheim,1992; Himmelfarb,1993) Oppenheim (1992) includes a single chapter on projective techniques, and Zimbardo and Leippe (1991) mention in passing the use of content analysis of written essays, transcripts of interviews, and other verbal responses. Nevertheless, these methods are increasingly used to obtain information about the attitudes of individuals (Ritchie & Spencer, 1994).

Such methods tend to involve only small groups or individuals; but examination of an *individual* attitude is not generally helpful because it does not allow the prediction, with any degree of reliability, of that individual's likely behaviour. However, the examination of *population* characteristics allows a degree of reliability in the prediction of the group's behaviour.

1.3.3 THE RELATIONSHIP BETWEEN ATTITUDE AND ACHIEVEMENT IN SCIENCE

As we have already seen some early research suggested that attitudes do not always determine behaviour (LaPiere, 1934) but current research indicates that modes of thought and situational factors may moderate the attitude change. In the particular area of children's attitude to science and achievement (behaviour) in science, the relationship between attitude and achievement has been the subject of considerable study over the last three decades, and there has been a very wide variation in the results obtained (see Table 1-3 on page 60). Various methods have been used to collect and analyse the data, and although much of the research has been carried out in the UK, some evidence comes from the USA, Brunei and Nigeria, where cultural differences may come into play.

Gardner (1975) in his review of the literature found only a weak relationship between attitudes and achievement in science. Fraser (1982), commenting on a meta-analysis by Willson (1980) found correlations ranging from –0.18 to 0.48, and no relationship between attitude and ability. Fraser investigated the relationship between attitude and IQ in 46 seventh grade classes in Australia, and found correlation coefficients ranging from 0.00 to 0.37, suggesting a weak relationship between attitude and ability. Schibeci in his later review (1984) drew a stronger link between attitude and achievement, finding correlations from 0.3 to 0.5. More recent studies report correlation coefficients ranging from 0.2 to 0.69 for attitude and achievement.

Table 1-3: Research into the relationship between attitude and achievement

Date	Author	Country of origin	Methodology/sampling	Pearson's r
1975	Gardner		Review.	0.00-0.37
1976	Brown	Scotland	2815 pupils in 40 secondary schools	0.32-0.36
1980	Willson		Meta-analysis	–0.18 to 0.48
1982	Fraser	Australia	Pupils from 46 classes	0.00 to 0.37
1984	Schibeci		Review.	0.3-0.5
1985	Pell	England	741 pupils in 16 secondary schools	0.25
1987	Keys	England and Wales	1000 pupils, random sample.	0.33
1992	Breakwell and Beardsell	England	1080 pupils in years 7-9.	0.58
1992	Daniels and Welford.	England	Sample size not given	0.16 (g), 0.04 (b)
1994	Asghar	Brunei	120 pupils in 4 secondary schools	0.35
1995	Weinburgh	USA	Review (Biology).	0.48 – 0.61(b), 0.46 -0.65 (g)
1995	Weinburgh	USA	Review (Physics).	0.34 (b), 0.37(g)
1996	Chidolue	Nigeria	375 pupils in 11 secondary schools	0.69 (partial)
1998	Koleoso and Olasehinde	Nigeria	110 pupils in 4 schools	0.65

On the basis of the evidence, it seems likely that attitude and achievement are significantly related, and that for UK secondary school pupils, Pearson's r is in the region of 0.3. Furthermore, it is possible that enjoyment of science is more closely related to achievement for girls than for boys.

How attitudes and achievements are linked is another frequently researched question. Does one precede the other, or are the two inter-related? Since the majority of the research is correlational it does not help to clarify this issue.

Shrigley (1990) suggested five perspectives:

- Attitude precedes behaviour
- Attitude is behaviour
- Attitude is not directly related to behaviour
- Attitude follows behaviour
- Attitude and behaviour are reciprocal

The majority of studies concerning attitudes to science base their methods on the first of these approaches; they use attitude questionnaires in order to measure attitudes, which in turn are related to behaviours such as achievement. Criticisms of such studies rest mainly on the lack of theoretical models behind the attitude measurement (Gardner, 1975; Schibeci, 1984; Krynowsky, 1988) and the inadequate validation of the measurement scales (Gardner, 1975 and 1995; Munby, 1983 and 1997). With improved validation of attitude scales and sound theoretical models now underpinning them *'the premise that attitude precedes behaviour dominates current research'* (Shrigley, 1990).

Some studies support the view that attitudes precede behaviour showing that earlier enjoyment of science is the best predictor of later achievement (Brown, 1976; Pell, 1985; Asghar, 1994). However, these studies cannot be said to reflect the current educational situation in England; Brown's research was conducted in Scottish schools nearly 30 years ago, Asghar's study was set in Brunei and the work of Pell relates to only a limited sample of schools, and pre-dates the introduction of the National Curriculum. On the other hand, Reynolds and Walberg (1992), in a longitudinal study involving a national probability sample, found that prior achievement predicted later attitude, rather than the reverse. This study is recent and involves a random and representative sample. However, the study was conducted in Australia, and so this result may not be typical of English schools. Such conflicting evidence makes it difficult to reach a definite conclusion on this matter, however it seems most likely that attitude and achievement are reciprocal, as suggested by Ausubel et al (1978).

The Educational Reform Act made testing of children at the ages of 11 and 14 the rule, and the results of these tests are frequently used as an indication of the performance of schools and teachers. Such testing has revealed an apparent fall in standards between Key Stages 2 and 3, focusing government attention on the primary - secondary transition (see for example Barber, 1999; Carvel, 2000). Attitude research may have an important part to play in understanding the changes in performance indicators across Key Stages since both attitude theory and empirical findings from science attitude research indicate a link between attitude and behaviour.

However, the political focus has tended to be on the performance and effectiveness of teachers and schools, and the pupils' views have rarely been given serious attention (Ruddock et al, 1996). There are indications that this may be changing, for example the Council for Science and Technology have taken care to include 'an assessment of the research literature about young peoples' attitudes towards science', in their analysis of the current situation, (The Council for Science and Technology, 1998). But, their own research was not able to find any recent large-scale studies of children's attitudes to science at the transition from primary to secondary school.

1.4 Summary

Two important and influential themes run through this account: first, the significance of psychological and philosophical changes occurring in education and in science, and second the political pressure for a common curriculum.
The first of these came from the research community, but the second appears to have been driven by political and economic concerns (see for example, Kelly, 1990; Jenkins & Swinnerton, 1998). The combined effects of all these changes should have been to reduce the transition gap, and make continuity in science education on transfer from primary to secondary school less problematic. In consequence, the learning experiences in science for children moving from one sector to another should now not change significantly, although in the past there were significant changes. According to the developments in attitude theory, such a shift in the teaching and learning of science should have had some observable effect upon children's attitudes to science over this time. In the next chapter, the research literature will be critically examined with such changes in mind.

CHAPTER 2. THE RESEARCH LITERATURE

2.1 Introduction

The aim of this chapter is to examine the research evidence concerning children's attitudes to school science, at and around the time of transfer from primary to secondary school. There is a huge body of research, which has examined factors affecting attitudes to science, but there is little that has focused on the effects of school transfer on science attitudes. There is general agreement among reviewers of attitudes to science research that the most important factors influencing children's attitudes to science are age, gender, home background, attitudes of peers and friends, classroom and pedagogical variables, and teacher variables. However, no review deals adequately with the research evidence showing that children's attitudes to science are closely linked with their attitudes towards school and education in general (for example, Garverick, 1964; Keeves, 1975; Keys, 1987; Simpson and Oliver, 1990). There is a considerable amount of research concerning the factors influencing attitudes to science and also to those influencing attitudes to school, and the effect of transfer on children's attitudes to school has been an important area of research over many years. So, in order to fulfil its aim, this review must take account of three separate research areas. These areas are attitudes to school, attitudes to science, and school transfer research.

This review first looks at the research investigating influences on children's attitudes to school. In the light of this evidence, the second section will focus on the research into influences on children's attitude to science. The third section examines research that specifically addresses changes in attitudes at the time of school transfer: firstly changes in attitude to school, and then changes in attitude to science. The area of most *direct* relevance to the focus of this thesis is that concerning school transfer, but each of the other areas has an important bearing on the theoretical model to be developed and used in the collection and analysis of the data. In view of the lesser relevance of the first two sections, and the very large amount of existing research into the influences on attitudes to school and attitudes to science, these two areas will of necessity be reviewed relatively briefly. However, the third section, concerning transfer studies will be more detailed.

Because of the extensive literature on attitudes to science and attitudes to school, and the very small number of transfer studies, certain criteria have been applied to limit the selection discussed in this review. Research studies have been selected on the basis of their relevance to:

- The effects of transfer between schools or stages.
- Upper primary and/or lower secondary pupils.
- UK schools

Other research studies are mentioned only when relevant data using the above criteria are not available, or are very limited.

Finally, in order to minimise the need for later repetition, the criteria for assessing the relative contributions of studies are given here, these are: date, methodology, and sampling. As regards date, more recent research, particularly research carried out since the Education Reform Act of 1988, should be more relevant to the current educational system than research carried out say, forty years ago. However, seminal works, such as the first major study of school transfer by Nisbet and Entwistle (1969), will be included because of their relevance to later studies.

Methodology is strictly speaking the subject of Chapter 3, and all the points mentioned here will be discussed in greater detail there. However, the main considerations as to the relevance of qualitative and quantitative methods are briefly presented here, in order to clarify the assessments made in this review. A fundamental aim of this study is to identify trends in attitude on transfer, and therefore quantitative survey research is of particular relevance. If random population samples are used, then it is considered acceptable to generalise from such research and this may allow trends and patterns to be identified. Qualitative research, because of its more intensive nature, usually involves smaller and often purposive samples, and it is not usually possible to make generalisations from small, purposive samples. However, such studies often provide valuable methodological triangulation, particularly in areas where little research has been conducted. Furthermore, qualitative research studies sometimes illuminate variables in a way that quantitative research cannot do, because they often probe individual issues more deeply. This may lead to clarification, for example where two or more variables are interrelated.

The size and nature of a sample have been referred to above, and need only a little more explanation here. Strictly speaking, it is only possible to generalise from a quantitative survey if it is based on a sample that represents the general population. Also, larger samples are generally subject to smaller errors. So, large, random population samples should provide the most reliable data for the purposes of making generalisations.

Finally, where the aim is to examine change, the relative values of cross-sectional and longitudinal studies must be considered. The problem with all cross-sectional studies is that data from different groups of people are compared. To equate a difference in the data from two different groups of people with change in data from one group on two different occasions is to make the assumption that these two groups are so well matched that they will think and feel in identical ways. However, cross-sectional studies that use large, random population samples are relatively reliable since, by definition, they are matched samples. Nevertheless, longitudinal studies are preferred when the aim is to investigate change.

2.2 Attitudes to school

In this section, the focus is specifically on research describing the influences on pupils' attitudes towards school and such attitudes are defined in the terms described in Chapter 1:

> *Attitudes are likes and dislikes, favourable or unfavourable evaluations and reactions to objects, people, situations or any other aspect of the world, including abstract ideas and social policies.*
> (Hildgard, 1996)

Thus, studies of children's worries about school, and adjustment to school are only included here where they also discuss children's favourable or unfavourable feelings about school.

Table 2-1, overleaf, summarises studies dealing with children's attitudes to school, but not those concerning attitude changes on transfer, which are discussed separately in Section 2.5.2.

Table 2-1: Summary of research into attitudes to school

Date	Author	Location	Methodology	Schools N	Pupils N	Summary of conclusions
1966	Murdoch	Scotland	Essay	33 S	552	80% of pupils expressed positive feelings about secondary school.
*1971	Barker Lunn	England	Questionnaire	23P	884	Attitude to school related to social class.
1975	Neal	Birmingham	Questionnaire	9S	375	88% of pupils expressed positive attitudes about secondary school
1977	Youngman & Lunzer	Nottingham	Questionnaire	6S	1500	Attitudes to school were mainly favourable, but 10% of pupils were 'disenchanted'. Ability not linked to attitude. Individual school differences, small schools were linked with children's more positive attitudes.
1979	Spelman	Northern Ireland	Essay & questionnaire	31S	3050	Alienation to secondary school was highest among those with low verbal reasoning and manual background. Girls may be more positive than boys.
1986	Brown & Armstrong	London	Essay	2S	89	92% of pupils expressed positive attitudes about secondary school. Boys and girls did not differ significantly in positive feelings.
*1990	Sammons and Mortimore	London	Questionnaire	50P	~2000	Attitude to school may be related to social class. Positive attitudes decline with increasing age. Girls more positive than boys.
*1994	Barber	Midlands	Questionnaire	Not known	8000	88% of pupils expressed positive attitudes about secondary school. Girls were more positive than boys. Positive attitudes declined with age.
1994	Blake	South of England	Interviews & essays	5P	100	At the end of KS2 the main feeling was one of acute anxiety about transition to secondary school.
1995	Keys et al	England & Wales	Questionnaire	80S	1000	82 % of pupils expressed positive attitudes about secondary school. Girls were more positive than boys.
*1996	Kinder et al	England	Interview	20 P & S	23 at P and 76 at S	An origin of disaffection may be related to learning activities and curriculum content , this may apply more to boys than girls.
*1996	Blatchford	London	Interview	Not known	175	Few gender differences in attitudes to school and school work. Differences related more to general attitude to school than to particular subjects. Small decline in attitude to school with age
1996	Gross & Burdett	Midlands	Questionnaire	1S	75	85% of pupils expressed positive views about secondary school.
*1997	West et al	London	Questionnaire & interview	6P	290 Y2	57% were 'very happy' or 'happy' about coming to school. More girls (66%) than boys (49%) were positive about coming to school. More minority ethnic groups (70%) than ESWI (46%) were positive about coming to school.
*1998	Smees and Thomas.	Lancashire	Questionnaire	69S	8681 from Y9	79% of pupils in Y9 'usually' or 'always' enjoy school.

N.B. P = primary school, S = secondary school

All these studies vary in a number of respects, most obviously being their respective dates, and hence the educational context in which the research was carried out. The other major differences between studies are the sample sizes and the methodology. Sampling was very varied, ranging from very small convenience samples to large, random population studies. Methodology included a variety of qualitative approaches, such as classroom observation, interviews, content analysis of essays, as well as quantitative questionnaire surveys. Finally, it should be noted that most of these studies concentrate upon attitude to school during the last year at primary school or the first year at secondary school, but that some covering a wider age-range (denoted by * before the date) have been included. The latter are included because they provide additional information about factors affecting attitudes to school. Despite differences in date, location, methodology, phase and size of sample, the findings are remarkably consistent, indicating that at least 80% of the year 7 children surveyed had positive feelings about school.

Where research was carried out using very small samples, or in a limited number of schools, the conclusions may be specific to that particular local area, or school (Brown & Armstrong,1986; Blake, 1994; Gross & Burdett,1996). Nevertheless, the overall picture is one in which the majority of children in year 7 have positive feelings towards school. However, there is clearly some variation, which might be ascribed to differences between location, schools or pupils. This variation and these differences are considered next.

2.2.1 Age

Where attitudes have been measured over a range of ages there is evidence from cross-sectional studies to indicate that positive attitudes decline with age, both at primary level (Mortimore et al, 1988) and at secondary level (Keys, 1987; Barber, 1994; Blatchford, 1996). However, the Lancashire study (Smees and Thomas; 1998) indicates that attitudes to school may have declined only slightly by year 9.

2.2.2 Gender

Some studies have indicated that girls' attitudes to school may be more positive than those of boys (Spelman, 1979; Barber, 1994; Keys, Harris & Fernandes, 1995; West et al, 1997). Three of these studies involved large samples of children from a wide range of localities, namely: a random population sample from schools across Northern Ireland (Spelman,1979), a large sample from the Midlands (Barber, 1994), and a large random population sample from England & Wales (Keys, Harris & Fernandes,1995). On the other hand, two studies found no significant difference between the attitudes of boys and girls (Brown & Armstrong, 1986; Blatchford, 1996), but these latter studies were limited to quite small groups, each within a specific environment. Brown & Armstrong investigated children from only two secondary schools in south west suburban London, a small boys-only school, and a large girls-only school. Blatchford's concern was with factors affecting the educational progress of black and white children, and his study centred on inner-city, working class and generally socially disadvantaged communities. These contradictions may be related to the sample size. When large numbers of schools are studied, then overall, girls appear to be more positive about school than boys; but when very specific types of school are studied these gender differences are not obvious. It is possible that there are differences between schools or areas that only emerge when these groups are studied at the individual level (Smees and Thomas, 1998). Hargreaves, Earl & Ryan (1996) have pointed out that groups who may be particularly at risk of alienation after transfer include low achieving boys, and girls with low self-esteem.

Some of the studies referred to above have also indicated that gender may interact with other variables. Keys, Harris & Fernandes (1995), investigating influences for the group of children who did not enjoy secondary school, found that they were significantly less likely to have a positive academic self-image than those who were positive about school. Blatchford (1996) observing that black children were more positive about school than white children, also noted that the black children had more positive views of their own ability. Blatchford linked this positive self-concept with parental support and encouragement, and Keys, Harris and Fernandes also noted that pupils who disliked school tended to have less supportive parents. So, there may be a combination of influences at work here: any observed differences may result, not simply from gender differences, but also from family influences, which may interact with those gender differences.

2.2.3 Ethnicity

There is little research in this area, but what there is suggests that, in the UK, ethnic minority groups may have more positive attitudes to school than those pupils from the majority culture (Blatchford, 1996, West et al, 1997). However, these samples may have been unrepresentative, and West et al (1997) acknowledge that their sample was too small to allow comparisons between particular ethnic groups.

2.2.4 Socio-economic status

As part of the first major study of the effects of transfer (Nisbet & Entwistle, 1967), Murdoch found some indication, with one very small group of pupils, that attitude to school and social class might be related. In a seminal study, involving a large sample of children, and statistical analysis, Barker-Lunn (1971) reported a positive relationship between attitude to school and social class. Later, attitude to school was linked to social class by Spelman (1979) and by Sammons and Mortimore (1990). In each of these two studies large samples of children were involved, and in both cases careful statistical analyses were used. However, both preceded the introduction of the National Curriculum, and Spelman's work was carried out in a selective educational environment (Northern Ireland). Spelman found that alienation from school was highest among those from manual backgrounds. Since his research involved a large sample of children (3,050) from a representative sample of schools and regression analysis was used to control for multiple variables, the findings may be considered to be reliable.

As indicated, the research was carried out in Northern Ireland, which has a selective 11+ system, and Spelman found that the type of secondary school attended was significantly related to social class, (for example children attending grammar schools had more positive attitudes than those attending secondary modern schools). Since Spelman made separate analyses for each type of school it is possible that different school types as well as social background were responsible for his findings. Indeed, Spelman found that learning environment was a significant factor, and that different educational environments influenced the extent of alienation, children attending Grammar schools being least alienated. However, since grammar school pupils were more likely to be from middle class families, social class and educational environment factors were confounded in this study. To summarise, there is some evidence that social background may influence attitudes to school but none of it reflects the present educational context in English comprehensive schools.

2.2.5 SCHOOL VARIABLES

Spelman's work indicated that school variables may have an important influence on attitudes, and this view has been supported by other research (Youngman & Lunzer, 1977; Brown & Armstrong,1986; Kinder, Wakefield & Wilkin,1996). These variables may be most conveniently categorised under the following headings:

- pastoral liaison strategies
- teaching approaches
- curriculum.

Numerous studies suggest that these school variables may have important effects on attitudes via continuity and progression, but do not deal directly with attitudes to school, and so they do not appear in Table 2-1, above. For example, in Chapter 1 the dip in progress on transfer was discussed and linked with effective liaison (page 51), and it will also be recalled from Chapter 1 that good liaison has been stressed as being beneficial to continuity and progression by many, from Plowden (1967) to SCAA (1996). There is also a little evidence suggesting that good liaison between feeder schools and secondary schools might have a positive influence on attitudes to school after transfer (Youngman & Lunzer, 1977; Brown & Armstrong,1986).

However, there is less agreement about the use of different teaching approaches. In particular, Galton and Willcocks (1983), suggest that the very different teaching styles at primary and secondary school might be a reason for the less positive attitudes to school at secondary school. In an ethnographic study of transfer, Measor & Woods (1984) suggested that attitudes to secondary school might be improved by a more integrated teaching approach in the first year.

However, their research focused on the changes for one group of children from one school only, and did not specifically address change in enjoyment of school. Youngman & Lunzer (1977) observed that, although this approach offered some advantage to children during the first few weeks at the new school, their data did not support the view that such organisational changes, taken alone, improved attitude.

As to curriculum, Kinder, Wakefield & Wilkin (1996), in a study of disaffection, noted that curriculum content problems, such as lack of relevance, stimulus and variety in learning tasks, may be important factors. Curriculum content problems were frequently given as reasons for truancy in the lower secondary, but were rarely mentioned by pupils at primary school.

2.2.6 Overview

Surveys, observation, analysis of interviews and essays have all been used to establish children's feeling about school. The majority of children appear to have very positive attitudes to school at both primary and secondary school; but some research has suggested that gender and social background may be significant influences, girls and children from higher socio-economic status (SES) backgrounds having more favourable attitudes. Research has also suggested that effective liaison and the relevance of the curriculum content may have positive effects on attitudes to school. Finally, there are some indications that the different teaching styles at primary and secondary schools may lead to less positive attitudes after transfer.

2.3 Attitudes to science

2.3.1 INTRODUCTION

Children's attitudes to science have been the subject of study for at least 50 years, and despite changes in the education system some of the trends and influences revealed in early studies appear to have persisted to the present day. For example, early studies indicated that girls appeared to have less favourable attitudes to science than did boys, and recent studies make the same suggestion.

As attitude theory and methods of measuring attitude were developed, studies of attitudes to science also accumulated. Eventually, in 1975, two major reviews of science attitude research were published, providing some much needed analysis of the research up to that time (Gardner, 1975; Ormerod and Duckworth, 1975). Later reviewers (Haladyna and Shaughnessy, 1982; Schibeci, 1984; Laforgia, 1988; Osborne et al, 1996) tended to follow the lead of those earlier reviews, and few additional influences were identified.

2.3.2 DEFINING ATTITUDES TO SCIENCE

Klopfer (1971) listed a set of behaviours associated with attitudes to science, including 'the adoption of scientific attitudes' and 'the enjoyment of science learning experience', which Gardner (1975) later clarified. Gardner pointed out that 'attitude to science' research had generally investigated two broad categories, which he identified as: attitudes towards science, and scientific attitudes. *Attitudes towards science* included a wide range of constructs such as attitudes to science careers, attitudes to science education and attitudes to specific issues such as 'nuclear energy' or 'environmental issues'. Gardner placed these in the same general category because they all involved some distinct attitude object, to which the respondent could react favourably or unfavourably. However, the second category, *scientific attitudes,* (for example, 'open-mindedness' and 'tolerance of the views of others') he suggested were better described as styles of thinking. Since this thesis is concerned with changes in attitude, this review will concentrate specifically on the research concerned with attitudes of children towards school science.

2.3.3 MEASURING ATTITUDES TO SCIENCE

Much research into attitudes towards science has involved quantitative survey methods, and less use has been made of interpretative studies. This may be because, more often than not, those studying attitudes to science are themselves scientists, trained in quantitative, 'objective' methods. However, it is also clear that while earlier research involved mainly quantitative methods, more recent studies have, from time to time, used qualitative approaches such as case studies and ethnography. This change in methodological emphasis may reflect changes in the research community's views about qualitative methods, and the 'present antipathy towards the statistical-experimental paradigm' (Cohen & Manion, 1994). As discussed in Chapter 1, 'measuring' attitudes is an uncertain business and attitudes to science have been approached from a variety of directions. Where questionnaires have been used, many have involved semantic differentials or Likert-type items that allowed respondents to say how they felt about various aspects of school science.

However, some have asked pupils to express subject preferences, attitudes towards subject teachers, intention to enrol in science classes, or career choices (Colley et al, 1994; Hendely, et al, 1995; Stables & Wikeley, 1998; Wikeley & Stables, 1999; Furlong & Biggart, 1999; Francis, 2000) and these may be less useful for measuring attitudes to school science.

Although these strategies have provided some useful information about interest in science, (for example, Francis (2000) used career choice as a means of showing gender differences in science interest, and Ormerod and Duckworth (1975) noted that physics and chemistry were two of the least popular subjects post-14), there are problems with such methods. It is possible for an individual with a very positive attitude to all school subjects to rank science as the least popular, and yet still have a more favourable attitude to it than another student who has a dislike for all subjects. Subject preference is less useful in longitudinal studies because of the potential change in the number and type of subjects that could be chosen from year to year. This is particularly important when moving from primary to secondary school where the choice generally becomes greater after the move. Subject preference changes under these circumstances may not necessarily be a reflection of anything more than greater available choice.

Liking for a particular teacher must surely emanate from a number of complex, and not necessarily related, variables: for example, the teacher's personality and appearance, the subject matter, the teachers' chosen pedagogy, and the classroom environment. What valid statements can studies of pupils' attitudes to teachers make about underlying attitudes to science? Furthermore, since a change of teacher is almost inevitable, for most children, this approach appears to be particularly unfruitful.

The remaining approaches mentioned above, enrolment intentions and career aspirations, may have relevance to older children but seem to be inappropriate for children aged 10 or 11 years. These children have no choice in the matter, science is on the curriculum and they must study it! As to career intentions, although some children have clear and unwavering ideas about their future, they are in the minority. Accordingly, studies falling into the categories mentioned above (i.e. subject preferences, attitudes towards subject teachers, intention to enrol in science classes, and career choices), will be discussed only where other research evidence is extremely limited.

2.3.4 INFLUENCES ON ATTITUDES TO SCIENCE

There is general agreement among reviewers concerning the most important factors influencing children's attitudes to science. The most recent review was written by authors in England and post-dates the introduction of the National Curriculum (Osborne, Driver and Simon, 1996). These authors note that:

> *The underlying factors of influence have not changed substantially over the last 25 years.* (Op. cit. p.7.)

These factors are age, gender, home background, attitudes of peers and friends, classroom and pedagogical variables, and teacher variables. Major reviews were published in the 1970's and the 1980's, (Gardner, 1975; Ormerod and Duckworth, 1975; Haladyna and Shaughnessy, 1982; Schibeci,1984; Laforgia, 1988). The earliest reviews (Gardner,1975; Ormerod & Duckworth, 1975) although very extensive, dealt with a pre-ERA system in which not all children studied science. Haladyna and Shaughnessy reviewed American research, and Schibeci's study was written from the Australian perspective.

The major influences to be discussed fall into three categories: personal, school and teacher influences, and are shown in Table 2-2 overleaf.

Table 2-2: The main influences on attitudes to science

Personal	School	Teacher
Achievement and ability	Classroom environment	Attitude to science
Age	Curriculum and pedagogy	Knowledge and understanding of science
Gender	Peer-group influences	Conception of the Nature of Science
Parental influences	Socio-economic environment	
Social class /cultural background		

These categories reflect the exogenous and endogenous categories adopted by Haladyna et al (1982), personal variables being generally outside the influence of the school (exogenous), but school and teacher variables being, to some extent, within the control of the school (endogenous). The exogenous variables reflect those found for general attitudes to school, and so it is likely that children's school attitude will affect their science attitude. The literature will be reviewed below within the categories shown in Table 2-2, and will take the early reviews, of the '70s and '80s, as an appropriate starting point.

2.3.5 Personal Influences

2.3.5.1 Age

The literature indicates a steady decline in favourable attitudes to science with age. Cross-sectional studies using random population samples have observed a small decline in positive attitudes between the ages of 9 and 14 years. The most recent of these studies, the Third International Maths and Science Study (TIMSS), indicates that the majority of year 5 pupils in English schools liked science (*liked or liked a lot* : 81%), and using similar tests for year 9 pupils, attitudes were slightly less positive (*liked or liked a lot* :78%), suggesting that positive attitudes to science may decline slightly between the ages of 9-10 and 13-14 years (Keys, Harris & Fernandes, 1997a and 1997b). A similar result was obtained in the Second International Maths and Science Study (SIMSS), when 10 years-olds in England were more likely than the 14 year-olds to agree that science lessons were interesting and enjoyable (Keys, 1987). A very large cross-sectional study of secondary aged children (Miller et al, 1999) and other, smaller cross-sectional studies have found similar results for secondary aged children: attitudes to science decline with age (for example, Breakwell & Beardsell, 1992; Francis and Greer, 1999a). These findings are consistent with those from longitudinal studies of secondary school children (Hadden, 1981;Doherty & Dawe, 1985; Kelly, 1986).

Studies focusing on children from countries outside the UK, with large groups of children and quantitative survey methods, indicate a similar decline in positive attitudes with age (for example in the USA, Butler-Kahle and Lakes, 1983; James & Smith, 1985; Yager & Penick, 1986; Simpson & Oliver, 1990; Greenfield, 1997). Since this factor is common to many countries, it may be unrelated to any particular educational system or curriculum and is perhaps a factor outside the control of the educational process. However, there appears to be some doubt about what happens to attitudes between grades 6 and 8. Perrodin (1966), who used a projective-type test with a total of 554 children from grades 4, 6 and 8 in the USA, concluded that:

> *In general it appears that fourth graders have very favourable attitudes towards science, favourable attitudes reach a peak in the sixth grade, and decline somewhat at the eighth grade level.* (Op. cit., p. 218)

This finding is slightly at odds with that of James & Smith (1985), who studied attitude changes between grades 4 and 12. They observed that the greatest decline in positive attitudes occurred between grades 6 and 7.

However, Simpson and Oliver (1985) looking at attitudes from grades 6 to 10, found no significant difference between attitudes in grades 6 and 7, and also that 'student attitude to science is most positive during grades six and seven and least positive during grade eight'. Overall, these studies suggest no major change occurring between grades 6 and 7 in the USA, and any disparity might relate to local or methodological differences.

Studies of attitude change for younger children (5 to 9 years-old) are less well represented. The work of Davies and Brember (1994a and 1994b) found no significant change in the scores for either boys or girls between the ages of 6 and 8 years. These children were from six randomly selected primary schools in one LEA. In all, 167 children were surveyed, using a 'smiley scale', on two separate occasions: in year 2 and then again, two years later, in year 4. However, in a recent qualitative study from the USA, it was concluded that very young children enjoyed science but that attitudes became more negative with age (Piburn & Baker, 1993). Piburn and Baker used semi-structured interviews with a cross-section of 149 children from kindergarten to grade12, whereas Davis and Brember used a longitudinal method, so the latter study is likely to be more reliable. However, at present there is little to go on, and it is recognised that the investigation of attitudes in very young children is problematic (West et al., 1997).

Studies of children in their last two years at primary school have produced more consistent results. Children in this age group tend to enjoy science at school; for example, Keys et al, (1997b) found that the majority of English children aged 8 or 9 years liked science. A report commissioned by the Australian National Board of employment (1993) found similar results for children in their last year at primary school. In the USA, a large national survey (Yager & Penick, 1986) found that science classes are perceived as being most fun by 9 year-olds.

In summary, it would appear that the relationship between attitude to science and age is unclear before the age of about 9 years, but that thereafter it seems to fall steadily with age. However, this research does not appear to have taken into consideration the research into more general attitudes to school. Since there is considerable evidence to indicate that children's attitudes to school in general decline with age, the observed decline in attitudes to science may simply reflect this more general decline in positive feelings about education, rather than a decline in enjoyment of science. In view of this lack of methodological control it is difficult to positively identify attitude to science as declining with age.

2.3.5.2 Gender

Gender has been identified as an important variable affecting attitudes to science (Gardner, 1975), and has since been studied extensively (Table 2-3, overleaf). Despite considerable changes in the science curriculum since Gardner's review, research continues to indicate that girls are less positive about science than are boys, (for example, Brown, 1976; Davies and Brember, 1994a and 1994b; Hendley et al,1995; Weinburgh, 1995; Woodward & Woodward,1998b; Francis & Greer,1999a).However, much of this research fails to take account of social influences such as stereotyping and peer and parental influences. Furthermore, some researchers report no difference in attitude to science between boys and girls (Breakwell & Beardsell, 1992; Miller et al,1999), and others report only very small differences (Collins, 1993 ;McMahon, 1999). Breakwell & Beardsell (1992) controlled for social class and this may account for their different findings; and the very large sample of Miller et al (1999) may have had the effect of smoothing out class differences. The two studies where only small differences were observed, (Collins, 1993; McMahon, 1999), were small case studies of the researcher's own

Table 2-3: Exemplars of research into gender differences in attitudes to science in UK schools

Date	Author	Country	Sample	Methods	Conclusion
1976	Brown	Scotland	n=2815 40 S	Questionnaire	Interest & enjoyment of science higher for boys
1981	Hadden	Scotland	n=1006 3 S	Questionnaire	No significant differences between B & G on basis of semantic differentials in primary or secondary school. He suggests that there are differences – but these don't seem to relate to attitude to school science.
1985	Dochery & Dawe	England	N = 269 1 S. Years 7, 8 & 11	Questionnaire	Boys more positive than girls in all three years.
1986	APU	UK	N=4572	Questionnaire - Line drawings, text & smiley faces.	Girls less familiar with 'scientific equipment' out of school. No support for the view that girls prefer to study biological topics and boys prefer to study physical science topics.
1986	Kelly	Manchester	n=1389. 10 S. Aged 11-14.	Questionnaire	Strong and consistent gender differences. Boys more positive. $p<0.01$
1987	Robertson	Scotland	N=1122 Aged 15-16	Practical tasks (Low achievers)	More similarities than differences between boys and girls on practical laboratory tasks.
1992	Taylor & Qualter	England	N=120 3 schools. Aged 7-13.	Questionnaire - Pictures	Practical tasks were seen as appropriate to boys by the majority of these children.
1992	Breakwell & Beardsell	England	N=1080. Years 7 to 9.	Questionnaire.	Questionnaires with missing data were excluded - final sample was 36% of original sample. No difference between B & G in liking of school science.
1993	Collins	England	N=30 1 P Aged 6-7	Researcher's own class. Draw and write about scientists.	11 drew f and 19 drew m scientist. All boys drew m. and most girls drew f. but 4 drew m. Researcher concluded that there were no obvious gender differences.
1994	Davies & Brember	Manchester	N=167	Questionnaire - Smiley scale.	Boys more positive than girls on both occasions.
1994	Colley, Comber & Hargreaves	England,	N=495 Aged 15-16	Questionnaire	Boys ranked maths, and science higher than did girls.
1995	Hendley et al	Wales	N=1038 8 S	Questionnaire	Boys more positive than girls about science overall, and about level of difficulty, practical, enjoyment, importance but not about reading & writing.
1996	Matthews	London	N=132 6 S	Draw a scientist and written responses	Less gender bias in drawings & writing than in previous studies.
1998	Woodward & Woodward	Wales	n=120. Year 6	Interviews for 3 consecutive years	Boys attitudes were more positive than girls' attitudes. But both were very positive and the differences were quite small.
1999	Stark	Scotland	N=2000	Questionnaires	Differences between boys and girls were small, but there were differences in preferred learning activities.
1999	Francis & Greer	Northern Ireland	n=1549, 24 S Years 8 to 11	Questionnaire	Attitude towards science in the school curriculum, higher for boys than girls ($p<0.05$).
1999	Miller et al	England	N>6000 Years 7 to 11.	Questionnaire	Overall no significant difference between boys and girls in any year except Y9. For enjoyment of science scale, girls more positive than boys in y7 and then fall below boys until y11 when they are the same. Only significant difference is in y9 & y10 where boys are more positive.
1999	McMahon	Bristol	n=43. 1 P Year 6.	Researcher's own class. Interviews, thought books, questionnaire.	Very little difference between G & B, except some girls referred to science as hard but boys did not.
2000	Francis	England, London	N=100 3 S	Semi-structured interviews. and subject preferences.	Least favourite overall ranking was 2nd for girls. 15 chose it, and 10 placed it as least favourite. Overall 4th for boys. 4 boys chose it and 2 placed it as the least favourite. Suggests a gender difference.
2001	Jurd	Colchester	N=535 9 P	Questionnaires and interviews.	Boys and girls had very similar attitudes to science.

P=primary school, s= secondary school

class, and differences within a single class are generally expected to be smaller than differences between classes, or schools (see for example, Aitkin et al, 1981; Goldstein, 1987) because of the background similarities of such children. Also, these studies involved young children; in particular, Collins (1993) worked with 6-7 year-olds.

There is evidence of gender stereotyped views of science and scientists being held by children as young as 6 to 8 years of age (Smithers & Zientek, 1991; Newton & Newton, 1992; Matthews 1996; Matthews and Davies, 1999; Miller & Budd, 1999), and that the scientist is most generally perceived as male (Matthews 1996; Newton & Newton, 1998; Matthews and Davies, 1999). There are indications that girls may now hold less stereotypical views than boys (Colley et al, 1994; Havard, 1996; Lightbody and Durndell, 1996; Whitehead, 1996; Gallagher, McEwen & Knipe, 1997; Miller & Budd, 1999). Gallagher, McEwen & Knipe (1997), suggest there may have been a reduction in such stereotyped views recently, but their sample included only Grammar school pupils in Northern Ireland, and this may have led to bias; it is also interesting that the girls in Catholic schools did not conform to the trend observed in the other schools surveyed. However, the research by Whitehead (1996) and Miller and Budd (1999) involved large samples of children from comprehensive schools across the UK, and show that boys are likely to hold stereotyped views throughout their school career, whereas such views are likely to decline for older girls.

Parental attitudes appear to operate in association with gender, and are powerful influences (Brown & Riddell, 1992; Mann, 1998; Barnes et al, 1999; Kutnick, 1999). There are suggestions that parents are more likely to encourage boys in scientific study (Breakwell & Beardsell, 1992; Mann, 1998), but that if girls are interested in science, then they are encouraged by parents to take up biology rather than the physical sciences (Barnes, 1999). When attitudes to the individual sciences are investigated, a consistent pattern is found: girls have greater interest in biological subjects and boys have greater interest in the physical sciences (Ormerod, 1976; Harvey & Edwards, 1980; Kelly, 1981; Ormerod & Wood, 1983; DES, 1986; Stables, 1990; Stark, 1999). However, such differences may result from parental expectations and gender stereotyping. Subject preference may be restricted by the masculine/feminine connotation, which every subject acquires (Riddell, 1992; Elwood & Gipps, 1999), and such gendered perceptions may be intensified on transfer (Measor and Woods, 1984). In particular, Measor and Woods observed that girls adopted negative attitudes to science in order to reinforce their femininity, and physics has often been singled out as intrinsically masculine (for example, Ormerod, 1976; Riddell, 1992).

Some studies have suggested that single-sex school environments may reduce the effects of stereotyping. Girls in a single-sex environment are more likely to choose to study physical sciences at A-level (Cheng et al, 1995), and the views of both boys and girls in single-sex environments are less polarised than in a mixed-sex environment (Stables, 1990; Kniveton, 1995 & 1998; Vlaeminke et al,1997; Scaife, 1998).However, this evidence must be balanced against other research which argues against a single-sex environment (Hannan et al, 1996; Robinson & Smithers, 1999) although the arguments presented tend to rest on academic achievement and personal development, rather than the issue of attitudes to science. Although there may *be 'no conclusive evidence to suggest that single –sex schooling is better than co-educational schooling'* [in terms of achievement] (Elwood and Gipps, 1999), on balance it seems likely that a single-sex environment may be helpful in forming more favourable attitudes to science among girls.

Finally, there may be social class differences that interact with gender (Fennema,1996; Arnot et al, 1999), although research indicating how attitudes to science are affected by the inter-relationship between gender and social class is extremely limited. Smithers and Zientek (1991) report a tendency for more sex stereotyping among young children from a manual background. Girls from lower social classes may be less likely to study science, or express preference for science subjects (Croxford 1997; Wikeley & Stables,1999; and 2000;Bentley reported in Hofkins, 1996)

Thus, the influences of society may be responsible for many of the differences between boys and girls, and to suggest that girls are inevitably less positive about science than boys may be to overemphasise one aspect of the research evidence. The research studies above appear to have given no consideration to the effects of more general attitudes to school. In the case of gender, research suggests that girls are likely to be more positive about school than are boys, so, if there really were no gender differences in attitudes to science then it might be expected that girls would also be more positive about science. However, there is no research to suggest that this is the norm, and although some studies indicate no difference between boys and girls, there are many indicating that girls have less positive attitudes than do boys. Therefore, the evidence points to a gender difference in favour of boys.

2.3.5.3 Ethnicity

Relationships between achievement and ethnicity have been usefully reviewed by Gillborn & Gipps (1996), and there is a well-supported view that some minority groups perform less well, on average, than those of the majority culture in science (e.g. Sammons 1994, Reiss 1993). However, studies concerning ethnicity and attitude to science are few, and the link between achievement and attitude is recognised as being, at best, only moderate (see Chapter 1, page 60).

Further, it is likely that factors other than ethnicity (for example, parental influence, gender and SES) are involved in both attitude and achievement. Kelly's1988 longitudinal study in the Manchester area, involving more than 1000 pupils, is one of the few major studies to examine ethnic differences in attitudes to science. She found some significant differences in attitude between the white, Asian and black students in her sample. One of the most important was that Asian boys expressed the greatest liking for science, and were more interested in learning about physical science than the other ethnic groups. However, as Kelly herself pointed out, with only 88 non-white, compared with 1,213 white pupils, her sample was too small to make any firm judgements. Later, Riley (1994), working with girls from three London schools, found that black girls were particularly keen on science and technology. A recent USA study provides some limited support for these findings (Catsambis, 1995). Catsambis used nationally representative data from the National Educational Longitudinal Study (NELS) of 1988 [1], and found that Afro-Americans and Latinos were more positive than whites about science. On the other hand, in Hawaii, with a group of whites, Japanese and Hawaiians, Greenfield (1996) found that whites were overall the most positive about science. However, Greenfield's sample although large (over 1000 students) was limited to 9 schools from 3 districts in Hawaii, whereas Catsambis used a national population sample,

[1] NELS-88 involved a national probability sample of eighth grade students across the USA with a sample size in excess of 16,000.

which was likely to produce a more reliable result. So, on this evidence whites may have less positive attitudes to science than other ethnic groups. However, none of these researchers took account of attitudes to school, which may have affected their results. As it will be recalled from Section 2.2.3, p.72, there is some evidence to indicate that differences in attitudes to school, may be related to ethnic background (Blatchford, 1996; West et al, 1997).

To summarise, it would appear that the research in this area is very limited; ethnicity may be an influence on attitudes to science but the data so far does not allow a firm judgement to be made. However, on the evidence to date, it appears that, in predominantly white countries, minority ethnic groups, particularly Asians may have more positive attitudes to science.

2.3.5.4 Socio-economic status

As with ethnicity, there is little evidence concerning the relationship between socio-economic status (SES) and attitude to science. Gardner's review (1975) reported a few references to SES, finding a positive relationship between higher occupational status of father and greater enjoyment of science, and Ormerod and Duckworth (1975) reported similar findings. However, those studies were from the late 1960s, and there have been changes in society since that time.

More recent studies provide conflicting evidence. In Australia, there are indications that attitudes to science are strongly related to SES, as above (Fraser, 1977, 1980). In contrast, Breakwell and Beardsell (1992) found that children from higher social class had less positive attitudes to science. Unfortunately, although their original sample was a cross-national sample of 1,080 children from years 7-9, only 36% of these children were included in the final analysis. Incomplete questionnaires were excluded from analysis, thus excluding from analysis those children who were less able to complete a questionnaire, and hence they may not have had a representative cross-section of society. Some studies have found no relationship between SES and attitude to science (Hadden, 1981) and others have found only slight relationships (Brown, 1976; Keys, 1987). The research suggesting no relationship between SES and science attitudes may have failed to find a relationship because of sampling problems. Hadden used only three secondary schools, and took location rather than socio-economic background as the basis for his conclusions. The studies of Keys (1987) and Brown (1976) used representative samples, and controlled for many variables using regression analysis, and furthermore, Keys took account of attitudes to school when analysing the data. Nonetheless, both studies pre-date the present educational system in the United Kingdom, and so may not represent the present situation.

However, the literature concerning children's subject preferences tends to support a link between SES and science attitudes. We have noted on page 77 that subject preferences are not an ideal vehicle for examining children's attitudes, but in view of the conflicting evidence about SES, these studies should be considered. It has been suggested for example, that children from more affluent backgrounds tend not to opt for lower status, non-academic subjects, and that science is regarded as an academic, high status subject (Abrahams, 1995). Furthermore, separate sciences have a higher status than general science, and physics and chemistry have higher status than biology (Maden, 1995). Croxford (1997 and 2000) observed an SES-related difference in the science choices made by children in Scottish schools, children from working-class backgrounds predominantly studied general science, but physical sciences were more likely to be studied by those from professional backgrounds.

Similarly, Cheng, Payne and Witherspoon (1995), in their analysis of science and mathematics choices at age16 for the England and Wales Youth Cohort Study, found that children of professional parents and parents with degrees were more likely to study physical sciences than were others. Evidence such as this certainly suggests that social background may have an influence on attitudes to science, and it is probable that lower SES is associated with less positive attitudes towards science.

2.3.5.5 Peer group influences

It has also been argued that peers will exert a fairly direct influence on an individual's attitudes to science (Keeves, 1975). A recent UK study found that having more scientifically minded peers had a positive effect on pupils' attitude to science (Breakwell & Beardsell, 1992), and this bears out earlier, American (Haladyna et al, 1982; Talton & Simpson, 1986), and Australian (Keeves, 1975) findings. Such limited evidence as exists tends to support the view that peer groups have a strong effect on attitudes to science.

2.3.5.6 Parental support

A recent analysis of the large data-set from the National Educational Study of 1988 (NELS-88) in America, (George & Kaplan, 1998), provides evidence to support the view that parental involvement has a significant, direct effect on science attitudes. Parental support of out-of-school science activities is seen as particularly influential. Several UK studies also see a strong relationship between pupil attitudes to science and parental support (Keys, 1987;Breakwell & Beardsell, 1992; Woolnough, 1994). All these research studies are in agreement that parental support for science activities has a positive effect on children's attitudes.

So, as with peer group influence, such evidence as we have tends to support the view that the home background is an important influence on children's attitudes to science.

2.3.6 School influences

2.3.6.1 Introduction

When the question is 'do individual schools have an effect on attitudes to science?' the evidence is apparently inconclusive.

Researchers looking at attitudes to science across small numbers of schools have found that that some differences seemed to be attributable to the schools, although they have been unable to identify specific influences (Hadden, 1981; Schibeci, 1989; Simpson & Oliver, 1990). In each of the first two studies, only two schools were involved, and insufficient data were gathered to identify specific variables connected with these schools. However, Hadden felt that the difference in attitudes might have been related to differences within the science departments, and, in Australia, Schibeci suggested that the local influence of background variables might be an influence on attitudes to science. However, in the USA, Simpson & Oliver (1990), in a longitudinal study involving 12 schools, found that as much as 73% of the variance in attitude was explained by within-school variables, although they were not able to clarify the relationships between individual school variables and attitudes.

However, when larger numbers of schools are involved there seems to be less evidence of generic difference. Brown (1976) in a survey involving 40 Scottish schools found that the school characteristics (size of intake, location, and denomination) had no significant effect on attitudes to science. In a study of attitude to technology, in 60 primary schools in the Netherlands, Wolters (1989) found that the influence of school variables (secondary school choice, liking for school) was very weak. Keys (1987) reported that "the association between school factors (class size, PTA social activities, location, region, size of year group and computers at school) and students' attitudes towards science were very weak" in a study of 181 primary and 147 secondary schools across England.

All of the above studies suffer from methodological problems: the first group of studies, finding differences between schools, looked at a wide variety of school variables, but involved only a few schools. Therefore, these researchers were unable to identify specific variables responsible for the differences. The latter researchers may not have been able to link school variables and science attitudes because they did not include the relevant variables. Although they investigated a large number of schools, they included very few school variables. Schibeci's suggestion that the local influence of background variables might be an influence on attitudes to science does not appear to have been taken far. Although the size and location of the schools were investigated, the socio-economic background of the school does not appear to have been considered.

So, there is no conclusive evidence among these studies about the overall effects of schools on attitudes to science, but, as will be seen in the following sections, at a more detailed level there are a variety of influences that do appear to be important.

2.3.6.2 CLASSROOM ENVIRONMENT

Research has suggested that the learning environment may be closely related to student attitudes. There is considerable evidence to support the view that the organisation and environment of the classroom has an important influence on attitudes from both quantitative studies (Haladyna & Shaughnessy, 1982; Simpson & Oliver, 1990; Tobin, Kahle & Fraser, 1990; Myers & Fouts,1992; Wong, Young & Fraser, 1997; Hanrahan, 1998) and qualitative studies (Piburn & Baker,1993). Although none of it comes from UK research, it might be expected that similar associations would be found in UK schools. The quantitative studies used reliable samples and multivariate analysis, and there was good agreement between both quantitative and qualitative work about the important influences.

This evidence indicates that open-ended laboratory activity, greater pupil autonomy and pupil-centred approaches in an organised classroom setting with clear, agreed rules have positive influences on pupil attitudes.

2.3.6.3 PRACTICAL WORK

There is some evidence to suggest that the use of practical work promotes more positive attitudes to science (Woolnough, 1994b; Gott & Duggan,1995; Parkinson et al., 1998). However, a study from Germany (Killerman, 1996) stressed that conceptual understanding does not always accompany the indiscriminate use of practical work. Killerman concluded that no single method tested in his research could account for both increased effective conceptual understanding in science and more favourable attitude and interest towards the subject. In this study, teacher-demonstrated experiments produced more effective conceptual learning in biology but had a negative effect on attitude, whereas lessons where the children carried out their own experiments had a strong positive effect on attitude but were less effective in terms of knowledge gains. Although pupils report that what they most enjoy about science is the practical work, their enjoyment may be related to the greater variety of teaching styles and the active approach used in such work (Cullingford, 1987).

Active learning is generally regarded as a means of developing positive attitudes; indeed, Woolnough (1994 b) has said:

> *...it is clear from the words of the students in the research cited in this book and from the accounts of their projects, that the active involvement in scientific activity...had an important, positive effect on their attitudes, their motivation and achievement.* (Op. cit., p.106)

Moreover, Murphy, (1994) has observed that *'practical work can play a crucial role in combating gender differences';* but she stresses the need for classroom strategies to take account of the differences in preferred styles of working of boys and girls. Girls' performance was found to be significantly higher than boys' performance where tasks were both active and open (Op. cit. p.141).

It would appear that the use of practical work enhances enjoyment of science lessons, but that careful planning and organisation is necessary if such practical work is to have any other benefits. However, the preceding section found that an organised classroom setting with clear, agreed rules also have positive influences on pupil attitudes. So there is no apparent conflict between these two approaches.

2.3.6.4 Collaborative or Group Work

There is considerable support for the view that collaborative or group work encourages positive attitudes and improves motivation for example, at the primary school level, see Galton & Williamson (1992), and at the secondary school Kyriacou, (1997).

In science education there are many supporters of the use of group work (for example, Kempa, 1990; Lazarowitz et al, 1994; Scaife, 1994; Solomon: 1994; Gott and Duggan,1995; Lord, 1998). However, the need for careful management for effective group work has been stressed by Wellington (1994):

> *Teachers commonly place pupils in small groups and assume that the group will work. Close observation shows that this is often not the case, especially in groups of three or more. One pupil may dominate while others play little part, for example, in planning, predicting or carrying out a practical. ...There are many other issues connected with group work – my general point here is that we cannot assume that groups are teams or that pupils share or rotate their roles in a group. In short, group work must be managed – it cannot be taken for granted.* (Op. cit., p. 137).

But care must be taken in defining 'group work', as Kyriacou (1997) points out,

> *Many might regard science practicals, usually involving two or three pupils working together, as a common example of small group work. However, many science practicals simply involve pupils carefully following instructions and directions given by the teacher. They thus offer little room for discussion and collaboration other than the co-operation required for the conduct of the practical. In fact small group work involving genuine collaborative learning occurs most often in English, history and social studies in the secondary school, ...* (Op. cit., p. 51).

Similarly, Gott and Duggan (1995) acknowledge the potential value of collaborative work noting that,

> *... the peer interaction that occurs in group work influences performance. Collaborative skills can enhance learning, providing support for the less confident pupil.* (Op. cit., p.61).

But they also differentiate between collaborative work and practical work when they say that although practical work may aid motivation and social skills it is not proven to assist the learning of concepts (Gott and Duggan, 1996); this latter view is supported by the work of Killerman (1996).

However, when cooperative methods are used Lazarowitz et al (1994) have shown that its use has a positive effect on attitude and motivation without any loss in academic achievement, and Lord (1998) has indicated improvement in achievement through the use of such methods.

Hanrahan (1998), in a qualitative study of 12 year 11 biology students, observed that although group discussion was thought to lead to deeper learning and greater student autonomy, in fact the way that the teacher implemented these strategies was vital, and that they are often constrained by teacher-centred methods of instruction. The management of group discussions has been emphasised by Solomon (1994), and Galton & Williamson (1992) have noted that research on collaborative working has offered little guidance to teachers about their role and that children needed to be taught how to collaborate. Thus, both teachers and pupils may require educating about the use of cooperative work.

Matthews (2001), in a study involving three year 7 classes (82 pupils) in a typical inner city state comprehensive school and three parallel year 7 classes used as controls, found that when boys and girls were shown how to work together cooperatively their enjoyment of science increased, and also that they felt more confident about working with the other sex.

Evidence from classroom observations of science lessons over many years indicates that boys tend to dominate both discussion and equipment (Whyte, 1985; Scaife, 1998; Reiss, 2000), and there are some small-scale studies that find girls and boys prefer to work in single-sex groups in science lessons (Moller, Anderson & Sorensen, 1995; Murphy et al, 1995; Matthews and Sweeney, 1997). These researchers also suggest that careful classroom organisation would be necessary to get the most out of group activities, since in mixed groups there is a danger that conflicts will reduce the effectiveness of the approach (Murphy et al, 1995; Alexopoulou & Driver,1997; Matthews and Sweeney, 1997). Collaborative work may be cooperative or competitive and there is evidence to suggest that competition works better with boys and co-operation works better with girls (Head, 1996; Fennema, 1996). This view is partly supported by the work of Alexopoulou & Driver (1997) who, in a study of 86 Greek secondary level students, found evidence to suggest that males and females respond to conflict within small group discussion in different ways. They found that boys were able to use conflict to make progress whereas girls needed consensus if they were to progress in their development of ideas in science.

These small-scale studies are supported by the results of a large quantitative study by Stark and Gray (1999). Reporting on part of the Assessment of Achievement Programme (AAP) in Scotland with approximately 2000 pupils at each stage, Stark found that discussing science in groups was enjoyed by almost half of the pupils surveyed in primary 7 and secondary 2. However, boys enjoyed this activity more than girls, at both primary and secondary level. This research evidence suggests that much of the current collaborative work may involve competition rather than cooperation.

To summarize: research evidence indicates that group work improves motivation and enjoyment, and that co-operative group work is particularly beneficial, but that teachers need to organise such work carefully if teaching is to be effective, and pupils need to be taught how to work co-operatively to ensure equality of opportunity for boys and girls.

2.3.6.5 CURRICULUM AND INSTRUCTIONAL VARIABLES

Gardner (1975) and Schibeci (1984) reviewed a considerable number of curriculum and instructional variables, but none appeared to have any significant influence on attitude to science. These reviewers suggested that teacher and pupil variables may exert more powerful effects upon attitudes than curricula and instructional materials, but no definite conclusions were reached. More recent research has not simplified the picture. Studies examining students' attitudes to science in relation to new curriculum or instructional materials comprise the largest part of attitude research; most of these studies come from America and the results have not been conclusive.

In the UK, two schemes of work may be important. Both have been widely used and there have been suggestions that pupils' attitudes to science might be related to the use of these schemes. These are the Salters Science Scheme (Salters), and the Cognitive Acceleration through Science Education project (CASE).

The Salters course uses everyday contexts as starting points from which to develop scientific concepts. The course emphasises the technological and societal aspects of science and uses a wide variety of learning strategies. Ramsden, (1992) used a questionnaire survey with pupils in schools carrying out trials of the Salters course. She found that the pupils using this scheme had very positive attitudes to science, and that there were only small differences between attitudes of girls and boys, indicating that this approach might reduce gender differences. She suggests that the Salters scheme increases pupils' interest and enthusiasm for science. However, since no comparison was made with a matched group who did not use the Salters scheme this suggestion cannot be confirmed. Ramsden later followed up her earlier work by interviewing some of the teachers in trial schools (Ramsden, 1994). The teachers were asked to comment on any changes they had observed in pupils' attitudes, as a result of using the Salters approach. The teachers generally found it quite difficult to make such judgements, although they were confident that their pupils were enjoying the current science lessons; but again, no comparisons could be made between similar pupils in Salters and non-Salters classrooms.

However, there was general agreement that the use of a wide variety of activities and greater personal autonomy appealed to pupils, as this comment from one teacher illustrates:

> *One* [of the pupils] *said the best thing about science was not having the teacher on your back all the time telling you what to do.*
> (Ramsden, 1994, p.11.)

The pupils' positive attitudes may have resulted from the use of this specific scheme, or from one or more particular aspect of the scheme such as the wide variety of teaching strategies. However, at present there is insufficient evidence to conclude that the Salters course itself has a positive effect upon attitudes.

The CASE approach, embracing the Piagetian model of cognitive development, encourages the development of thinking from concrete to formal operational by means of a set of activities designed to enhance 'thinking skills'. The activities are designed as enrichment to regular science lessons rather than as a replacement for them, generally occurring once every two weeks. Research has yielded evidence indicating that the CASE scheme improves later achievement (Adey, Shayer and Yates, 1989a), resulting in its widespread use. It has been estimated that upwards of 10% of all secondary schools in the UK have been involved in the CASE CPD programme (McLellan, 2000).

However, Adey and Shayer have been criticised for failing to give an adequate account of why some pupils benefit more than others (Leo & Galloway, 1996; Jones and Gott, 1998). Leo and Galloway have suggested that motivational style might provide the missing explanation, arguing that for children with a 'learned-helpless' motivational style, problems of motivation were likely and therefore that such motivational effects might reduce the effectiveness of CASE for some children. Rogers et al (1994) have shown an increase in learned helplessness at the time of transfer. Jones and Gott have suggested that context might have an important effect, in particular the extensive use of group work. At the time, Adey rejected both motivation theory and context as adequate explanation of the effects of CASE (Adey, 1996; Adey, 1997), although the effect of the social environment has been recognised as an important influence (see for example, Solomon, 1994; White,1988; Kyriacou,1998; Shayer, 1999). Such criticisms have led to further research into the effects of motivational style on CASE, which is currently in its early stages (McLellan, 2000). McLellan indicates that there are striking differences between CASE and non-CASE schools; the former have a higher proportion of students with adaptive motivational patterns, who might make better use of the CASE intervention. Further, she has observed that classroom environment may influence pupils' goal adoption, emphasising the importance of the teacher.

The effects of the CASE scheme on attitudes remains unclear since evaluations by Adey and Shayer have concentrated on the effects on achievement. However, a qualitative study suggests that girls may respond more negatively than boys to CASE (Sharp, cited in Whitelegg, 1996); interviews were conducted with groups of pupils from a girls' only school and from a co-educational school. Since this study deals with such a small sample and is still in progress it is too early to draw any conclusion from these results.

To summarise, the CASE scheme appears to have beneficial effects on students' achievement, but its relationship with students' motivational style and attitude to science is not yet clear.

2.3.7 TEACHER INFLUENCES

2.3.7.1 INTRODUCTION

The quality of the teacher has been identified as a particularly important influence on students' attitudes to science (Haladyna et al, 1982; Parkinson et al, 1998), and also as very important in the promotion of learning (Hallam & Ireson, 1999). 'Quality' is rather a nebulous descriptor, which refers to both the teacher's knowledge of the subject of science[1], and their feelings and beliefs about science and science teaching. For Haladyna et al, (1982), it meant teacher enthusiasm for science, and the student's respect for teacher's subject knowledge.

Osborne et al (1996) suggested that 'good teaching' was a positive influence on pupils' attitudes to science, adding that pupils were influenced by teachers' subject confidence. Wragg et al (2000) observed that, from the pupils' point of view, subject knowledge was one of the most important attributes of a good teacher. Subject knowledge has been identified as an important influence on classroom practice (e.g. Shulman, 1986; Bennett and Turner-Bisset, 1993).

Several kinds of subject knowledge were suggested by Shulman (1987) including content knowledge, and pedagogical content knowledge, which he describes as, 'that special amalgam of content and pedagogy'; and later as ' ... the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge into forms that are pedagogically powerful...' There is considerable agreement that pedagogical knowledge is important (Mant & Summers, 1995; Harlen, 1997), and that it depends upon subject knowledge.

Finally, technical competence and teachers' own beliefs and expectations (Hallam and Ireson, 1999) were regarded as important in the more general context of learning outcomes.

In this review, teacher quality will be taken to refer to content knowledge, pedagogical knowledge, confidence, and beliefs. Research into subject knowledge (content and pedagogy) and confidence in science teaching has tended to focus on primary teachers, who since the 1988 Act, have had to take on a wider range of science teaching than they might previously have been used to. Research into beliefs about science and science teaching has included both primary and secondary levels in similar proportion.

2.3.7.2 SUBJECT KNOWLEDGE

Several recent studies of practising primary teachers' knowledge of science have shown that primary school teachers are often ill equipped in terms of background knowledge, as recognised by HMI in 1978 (see Chapter 1, page 34). The Primary School Teachers and Science (PSTS) Project at Oxford University has published a variety of papers indicating that the understanding of concepts shown by primary teachers is often weak. For example, Kruger et al (1990) found that only 11 of 159 primary teachers questioned about force and motion believed that there is no net force acting on a car moving at a steady speed. In another publication for the PSTS project, Lenton and McNeil (1993), using a questionnaire about biological concepts, observed that 74% of the 125 teachers responding believed that a plant's food source comes from the nutrients in soil.

Teachers recognise their difficulties with the subject matter. Shortly after the introduction of the Science National Curriculum a large survey of primary teachers' perceived competence (Carré et al, 1989), found that teachers felt most competent in teaching English and Maths, whereas in science teaching feelings of competence were among the lowest. In a follow-up survey (Bennett et al, 1992), with almost 50% of the original sample, found that feelings of competence in Science teaching had improved. The authors attributed the change in ranking to,

> *...the allocation of resources, both human and material, to science teaching, together with the provisions set out in statutory orders...*
> *(Op. cit., p.58.)*

Later research with a large sample of primary teachers in Scotland (Holroyd & Harlen, 1996) found a correspondence between their rankings of 1993 and those of Carré et al (1989). This research also linked science background and understanding: those teachers in the top one-third (on the basis of understanding) were likely to have some science background, whereas none of those in the bottom one-third had a science background.

Research has found similar difficulties among pre-service primary teachers. Young (1998), in a questionnaire survey of 115 first-year primary teaching undergraduates, observed that those with a science background were the most positive and least anxious about teaching science. Lloyd et al (1998) surveyed pre-service primary teachers in both Singapore and the UK, noting that those students who had elected to study science to GCE O- level or A-level were slightly more knowledgeable. However, the introduction of compulsory school science may have led to an improvement in the general science knowledge of pre-service primary teachers (Murphy et al, in press). In this study, the science subject knowledge of two groups of initial teacher training students with contrasting experiences of school science was compared, and Murphy et al found that those students who had experienced compulsory school science from the ages of 11 to 16 had significantly higher scores than students for whom school science was optional at secondary level. However, the study also found that almost all of the students tested still found difficulty with many basic science concepts, such as the circulatory system, light, sound, and electric circuits.

Specialist science teachers in secondary school asked to teach a science subject outside the area of their own specialist knowledge may suffer from similar problems (Denley & Bishop, 1995; Finlayson et al, 1998). Denley and Bishop described the case of a specialist biologist preparing to teach 'forces' to a year 9 class:

> *As a biologist she had little background knowledge of the topic and readily admitted her ignorance.* (Op. cit., 1995, p5)

However, her lack of knowledge of the pedagogical reasoning underpinning the school's scheme of work meant that despite her good grasp of theory she still had problems in being able to present this topic to the class, as this comment shows,

> *...on Thursday I've got to do a lesson on more than one force acting on an object, and looking at other people's work, and looking at the work scheme I haven't got a clue because I don't know the equipment and I don't know the practical.* ...(Op. cit., p. 6.)

Lack of subject knowledge and lack of pedagogical knowledge were also problems for the pre-service teachers questioned by Finlayson et al (1998).
They also observed that many of these students had less confidence in teaching outside their specialist area, and this issue of confidence in teaching science is the subject of the next section.

2.3.7.3 CONFIDENCE

Confidence in teaching science is closely related to subject knowledge, and the two have been linked in several of the studies discussed in the previous section (Carré et al, 1989; Bennett et al, 1992; Holroyd &Harlen, 1996; Denley & Bishop, 1997; Finlayson et al,1998; Young,1998).

In particular, Harlen & Holroyd (1997) showed that overall levels of confidence appeared to be significantly influenced by science knowledge. There are suggestions that there has been an improvement in confidence since the introduction of the National Curriculum (Carré & Carter, 1993; Littledyke, 1994). However, there are particular areas of difficulty, and Carré & Carter pinpoint basic physics concepts as a curriculum area causing particular problems. Appropriate support appears to improve even these difficult areas: the (PSTS) Project demonstrated that appropriate INSET in teaching electricity could help to develop subject knowledge and confidence (Summers, Kruger & Mant, 1996).

Experience was also shown to be an important factor: in a comparison of the confidence of PGCE students and practising primary school teachers, the teachers were more confident than the students about all aspects of National Curriculum science (Sorsby and Watson, 1993). The suggestions from these surveys that experience and support are important in improving teachers' confidence are supported by case-study research in Australia. Appleton (1995) found that pre-service teachers' confidence improved when they were given a special 'science education' unit about energy.

Ginns & Watters (1998) found that support from colleagues and positive feedback from pupils had positive effects on the attitudes to science teaching of four practising teachers. Appleton and Kindt (1999), who interviewed nine teachers during their first 18 months in teaching, observed that self-confidence was related to science knowledge, and that after some teaching experience self-confidence tended to improve. However, if teacher self-confidence was very low, then science teaching was so difficult that some abandoned it altogether.

Teachers' confidence levels have also been linked with their teaching strategies (Harlen & Holroyd, 1997). These authors suggested that primary teachers' low confidence led to restricted practices in the classroom. They observed that teachers appeared to have found ways of teaching that minimised the risk of challenge to their confidence and understanding, and identified various coping strategies. For example they compensated by doing less of a low-confidence aspect by doing more of a higher-confidence aspect, emphasising expository teaching, and avoiding all but the simplest practical work.

In summary, teachers often lack sufficient subject content knowledge to teach effectively outside their own specialist area. Insufficient subject knowledge is often associated with less confidence in teaching and this in turn has been linked with specific teaching strategies within the classroom.

2.3.7.4 Views about the nature of Science

At the beginning of this section about teachers it was suggested that teachers' own beliefs might have an important part to play in the concept of 'teacher quality'. In this sub-section the relevance of teachers' beliefs about the nature of science in the context of their classroom approaches will be considered.

Lederman (1992) reviewing teachers' views about the nature of science observed that there seemed to be an implicit assumption in many studies that a teacher's classroom behaviour and decisions are influenced by their beliefs about science. He concluded that,

> *Debate still surrounds the issue of whether a teacher's understanding of the nature of science is directly related to the development and/or performance of [specific instructional behaviours, activities, and decisions implemented within the context of the lesson] or other aspects of classroom practice.*
> (Op. cit., p.351.)

Recent research with teachers at secondary level does not contradict his conclusion. Case studies in the USA (Brickhouse, 1991; Abd-Khalick et al, 1998), have shown no definite relationship between teachers' conception of the Nature of Science and their classroom teaching. Equally, research in Spain (Mellado, 1998) has been unable to show any clear relationship between teachers' conceptions about teaching science and their classroom behaviour. However, a researcher in Palestine (Hashweh, 1996) has suggested that teachers with a constructivist view use a wider range of explanatory techniques, although the number of teachers involved in this study was very small to allow such a conclusion.

The few studies of primary pre-service teachers views of science (Bloom, 1989; Abell & Smith, 1994; Murcia & Schibeci, 1999) found that science was predominantly viewed as a process of discovery in which the truth about the world is uncovered. But although links between views about science and beliefs about teaching science have been suggested, there does not appear to be any evidence to connect these in these research studies. Livesey (1981) investigated the influence of the primary teacher on children's attitudes to science and, although unable to demonstrate any significant influence connected with teachers' views, her results suggested that girls seemed more interested in science when taught by a woman rather than a man, whereas for boys the sex of teacher made no significant difference. However, Livesey had only a small sample of 15 teachers to compare.

What seems clear from the research is that many primary teachers have a rather limited view of the Nature of Science. Abell and Smith (1994) asked pre-service primary teachers to answer the question, 'What is science?' and found that their students were confused about science as a discipline, often failing to distinguish between science and science education. They commented that,

> *Some responses were difficult to categorise. What at first appeared to be a discussion of science turned into a statement about education...*(Op. cit., p.481)

This same point was made about practising primary teacher's views of science (Hayes and Johnston, 1995). These researchers also found that their group of practising teachers in England saw science as process-oriented, discovering facts about the world. Laplante (1997) in a small study, observed 2 kindergarten teachers in a naturalistic setting, and found that these teachers saw themselves in the same role as their pupils, as 'consumers of knowledge', and that they viewed science as a body of knowledge to be transmitted.

Since secondary teachers are science specialists they might be expected to have clear views on the nature of science. However, Lakin and Wellington (1994) found the teachers in their study lacked knowledge of the nature of science and were unclear about scientific method. This study involved only four teachers but is supported by work in the USA (Kimball, 1968; Loving, 1991).

Kimball (1968) found that science teachers were,

> *...at least as understanding of the nature of science as their professional science counterparts* (Kimball,1968, p.119)

But that, in general, there was a poor understanding of the nature of science by *all* science graduates, which he suggested might be due to inadequate teaching about the nature of science at university. This idea was supported by the work of Loving (1991).

In summary, the research evidence concerning the influence of teachers' views about the nature of science on their pupils' attitudes to science, is still open to question, since the research has been scarce and often relied upon pre-service teachers rather than practising teachers. Furthermore, research has tended to rely on surveys with very small samples or on small numbers of case studies. However, it seems likely that teachers of science, at all levels, have inadequate knowledge concerning the nature of science.

2.4 Transfer studies

2.4.1 Introduction

In an ideal study of the effects of transfer, the attitudes of a large group of pupils would be assessed on a number of occasions over the transfer period, in a way that enabled individual changes to be observed. Although a few studies have used this longitudinal approach more have used cross-sectional methods. Some cross-sectional research has focused on children in their final year at primary school and has investigated feelings just before transfer; such studies are described here as prospective. Prospective studies look at children's expectations, and these are likely to be based on the amount of information they have received and the sources of that information. Such studies may provide valuable insights into children's perceptions of transfer, education and science lessons, but they cannot provide any comparison of attitudes before and after transfer.

Other research has investigated the attitudes of children in their first year at secondary school, looking back over the time of transfer and making comparisons between memories of primary science and their current views of secondary science; these are described as retrospective studies. There are two major problems with retrospective studies: first, they depend on memory, and it is recognised that memory is extremely unreliable (Baddeley, 1979). Second, any view of the past is interpreted in terms of the present (Hindley, 1979). The view of primary school through the eyes of the newly promoted secondary pupil is likely to be susceptible to both these problems.

Finally, there is a group of 'before-and-after' studies, which have investigated attitudes for separate groups of children in different primary and secondary schools at the same time, and made comparisons between them; these are described here as cross-sectional studies. Such studies cannot illuminate changes in attitude at the time of transfer, but they do offer information about attitudes at primary and secondary school that has been obtained in the same way and at the same time. If cross-sectional samples have been well matched, or consist of large population samples, then they may approximate to the changes occurring on transfer. But longitudinal studies, where the same children express their views at two or more different times, are likely to give a more valid picture of the changes in attitude than are other types of study.

2.4.2 CHANGES IN ATTITUDE TO SCHOOL ON TRANSFER

As can be seen from Table 2-4 below, there has been a considerable amount of research into children's attitudes to school. Few studies have been prospective but there have been many retrospective and cross-sectional studies, as well as a considerable number of longitudinal ones. Table 2-4 lists the major studies carried out in the UK.

Table 2-4: Exemplars of research into attitudes to school in the UK

Date	Author	Location	Methodology	Sample	Type
1988	Inkson.	England	Discussion	Not known	P
1992	Short.	England	Essays	N=124	P
1998	Naughton	Ireland	Questionnaires	N=110	P
1966	Murdoch.	Scotland	Essays	N=60	R
1977	Youngman. & Lunzer.	Nottingham	Questionnaire	1500	R
1979	Spelman.	Northern Ireland	Essays and questionnaires	3050	R
1988	Bruce & Hobbs.	Scotland	Questionnaire	Not known	R
1994	Taylor.	England	Written responses to questions	92	R
1995	Lee, Harris and Dickson.	England	Interviews	164	R
1996	Ruddock, Chaplain and Wallace.	England	Interviews	~80	R
1999	Schagen, and Kerr.	England	Discussions & questionnaires	~60	R
1995	Keys, Harris & Fernandes.	England & Wales	Questionnaire	1000	C
1969	Nisbet & Entwistle	Scotland	Questionnaires	2000+	L
1975	Neal.	Birmingham	Questionnaire	375	L
1981	Jennings & Hargreaves.	England	Questionnaire and essays	92	L
1983	Galton & Wilcocks.	England	ORACLE	Not known (58P)	L
1984	Measor and Woods.	England	Ethnographic	Not known (1S)	L
1986	Murdoch.	England	Interviews & profiles	42	L
1986	Brown and Armstrong.	London	Essay	89	L
1988	Alston.	London	Questionnaires	1266	L
1990	Nicholson.	Wales	Interviews	Not known (4P)	L
1996	Gross and Burdett.	England	Questionnaire	75	L
1997	Hugginsand Knight.	England	Questionnaire	106	L
1999	Galton, Gray & Rudduck.	England	ORACLE	300	L

P= Prospective, R = Retrospective, C= Cross-sectional, L=Longitudinal

2.4.2.1 PROSPECTIVE STUDIES

Three prospective studies have explored expectations about transfer from the viewpoint of the children still at primary school (Inkson, 1988; Short, 1992; Naughton, 1998). Although they had different aims and used different methods, the information concerning attitudes to transfer was quite similar. Inkson aimed to develop a procedure to identify sources of anxiety among children who were about to transfer, and interviewed small groups of children. Short was interested in the attitudes of different ethnic groups to transfer, and he interviewed, and analysed the essays of 124 children from three primary schools in London. Naughton asked whether boys and girls might have different anxieties and expectations, using a questionnaire with 101 children from four primary schools in Ireland.

The main anxieties expressed related to the size and number of school buildings and getting lost, bullying, relationships with new teachers and peers, and aspects of academic work (level of work and homework), and getting into trouble. Expectations of transfer were doing new subjects, making new friends, sport, going from class to class, school trips, more responsibility, and more freedom. However, Inkson and Naughton observed that boys were more likely to comment about sport, whereas girls more often commented on the greater degree of personal autonomy; and in Short's research, more boys than girls mentioned worries about getting into trouble. Short found no obvious differences between the different ethnic groups in his study.

These three studies indicated that academic work featured among both negative and positive aspects of transfer. Children looked forward to new subjects, but at the same time worried about the level of difficulty and the amount of homework. Boys looked forward to more sporting activities, but girls hoped for more autonomy at secondary school.

2.4.2.2 Retrospective studies

A number of researchers have investigated the effects of transfer on attitude from a retrospective point of view (Murdoch, 1966; Youngman & Lunzer, 1977; Spelman, 1979; Bruce & Hobbs,1988; Taylor, 1994; Lee, Harris & Dickson, 1995; Ruddock et al, 1996; Schagen & Kerr, 1999). A variety of qualitative and quantitative methods have been employed in these studies, but the findings are quite similar. In general, most pupils said that they enjoyed secondary school as much, or more, than primary school, and only a small number expressed negative views about transfer.

Two early studies reported that pupils were predominantly positive about transfer, and that girls were more positive about transfer than boys (Murdoch, 1966; Spelman, 1979). These authors used content analysis of essays written by pupils during their first year at secondary school. These studies were undertaken some time ago and under rather different conditions from those which now prevail. Murdoch's work was among the very earliest studies of the transfer process, before the Plowden Report and before the many improvements in liaison and transfer arrangements. Spelman's study was carried out in a system of selective education, and he observed that the effects of transfer varied very significantly between schools of different types. So, in view of the educational changes outlined in Chapter 1, it might be expected that later research would find a rather different situation.

More recent studies have indicated that the majority of children seem positive about the transfer to secondary school (Harris & Ruddock, 1993; Lee, Harris & Dickson, 1995; Ruddock, et al,1996; Schagen & Kerr, 1999). Harris & Ruddock (1993) found that only a very small number of pupils wished they were still at primary school, most had settled when interviewed in year 8. Schagen & Kerr (1999) observed that the large majority of the children they spoke to enjoyed subjects more at secondary school than they had at primary; they interviewed groups of pupils from ten different secondary schools. Lee, Harris & Dickson (1995) said that secondary school pupils seemed quite confident after transfer and that their worries had not been confirmed; many said that there were few or no differences after transfer.

These retrospective studies suggest that the transfer process is not a problem for most children, but that there may be a group who find secondary school less enjoyable than primary school. Girls may find the transfer more enjoyable than boys.

2.4.2.3 Cross-sectional studies

There are some cross-sectional studies where comparisons can be made between the responses of groups of children in both sectors; but in general, caution must be exercised when drawing conclusions from such studies because of the nature of cross-sections. However, because of the large random population sample used by Keys, Harris & Fernandes[1] (1995) their findings are likely to be quite reliable. Their results indicate only a small decline in attitudes to school between year 6 and year 7. For example, when 'Strongly agree' and 'Agree' statements were combined the results obtained are shown in Table 2-5:

Table 2-5: Some results from an attitudes to school survey

Statement	Y6 %	Y7 %
I am very happy at school	73.3	71.9
Most of the time I don't want to go to school	29.1	35.9
On the whole I like being at school	81.2	82.2
School is a waste of time for me	2.9	3.1
School work is worth doing	91.5	92.5
The work I do in lessons is a waste of time	3.7	2.4

(Source: Keys et al, 1995)

Girls were significantly more likely than boys to express positive attitudes to school in both year 6 and year 7, as indicated in Table 2-6, below:

Table 2-6: Gender differences in attitudes to school

Statement	Y6 Boys %	Y6 Girls %	Y7 Boys %	Y7 Girls %
I am very happy at school	70.0	76.7	68.2	75.7
Most of the time I don't want to go to school	34.8	23.5	38.3	33.8
On the whole I like being at school	80.5	82.1	81.3	83.0

(Source: Keys et al, 1995)

[1] These authors used the same questionnaire with 1250 pupils at 85 primary schools and another 1000 at 80 secondary schools.

These results support the general findings of the retrospective studies: i.e. the majority of children appear to enjoy school, there is a slight decline in favourable attitudes after transfer, and girls appear to enjoy school more than boys do.

2.4.2.4 Longitudinal studies

Here again there is considerable variety in the research methods used in this type of study, for example the size of the sample, and the type and number of schools involved. Researchers have used content analysis of essays, interviews and questionnaires, and there have also been some interesting ethnographic studies, for example, Measor and Woods (1984), but these dealt with issues outside the scope of this review. Samples have varied from two groups of 46 pupils in each of two schools, to over 1000 pupils in eighty schools. Where few schools are involved it is possible that individual teachers might affect children's feelings about transfer (Nicholson, 1990), or that the characteristics of the schools might lead to differences in adjustment to transfer (Neal, 1975). However, despite these differences the similarities between the results are quite striking.

Brown & Armstrong (1986) made a content analysis of the essays of 89 pupils – first at their six feeder primary schools and later at their two secondary schools; individual children were tracked and 7 children, 8% of the sample experienced serious difficulties in settling. Boys and girls did not differ significantly in expressed worries and positive feelings. Overall, 10% said they preferred secondary school to primary school, and 25% said secondary school was better than they had thought it would be. Coincidentally, in another content analysis of essays from children in 5 secondary schools (Bruce and Hobbs, 1988) researchers found that after transfer 25% of the children said that their fears about transfer had been unfounded.

Murdoch (1986) interviewed 42 pupils who had moved from two primary oriented middle schools to five upper schools. She found that their reactions to school were not necessarily stable, that is to say, some who were anxious before the move became excited after the move. More than three-quarters of the children became excited or optimistic by the end of the first year after transfer, even if they had been anxious before. 12 children, 29% remained stable, and 5 children (12%), became more negative.

Researchers who have used questionnaires to investigate attitudes for the same group of children before and after the move to secondary school have generally found only a small decline in enjoyment of school on transfer. One of the earliest studies of this type was a large survey of schools in the Birmingham area (Neal, 1975). Before transfer, 23% of the pupils made favourable comments about secondary school and 10% made unfavourable ones. After transfer the responses indicated that 88% of children had enjoyed their first year at secondary school and only 5% expressed negative feelings. Unfortunately, the questionnaire responses do not allow a detailed interpretation of the change in feelings experienced on transfer, but they do appear to be quite similar to the findings of the retrospective studies.

Jennings and Hargreaves (1981) were able to take an experimental approach, comparing two groups of children. The experimental group comprised 46 children transferring from junior to a secondary comprehensive school, and the control group consisted of 46 children from a second junior school that was reorganised to become a middle school. Thus the control group simply moved classes in the same school. The two samples were matched in terms of age and ability. The attitude to school of the control group rose slightly, and that of the experimental group fell, the differences between the control group and the experimental group were statistically significant. The two groups also made rather different comments about the changes on transfer in essays; experimental group subjects were likely to make neutral or negative comments whereas control group subjects made positive ones. The children in the control group had less positive attitudes to school than the experimental group at both stages, and this could indicate that the reorganisation had affected the attitudes of these children adversely. However, the content analysis of essays supported the questionnaire findings that the experimental group were less positive after transfer. This study is only indicative of the short –term effect of transfer, since the questionnaires and essays were completed in June and October only, and involved only a small sample of children from one school environment.

Galton and Willcocks (1983) made a longer-term study involving six transfer schools, and here the effects of transfer in terms of favourable and unfavourable attitudes are more clearly seen. Part of their results is reproduced below (Table 2-7). Numbers refer to the percentage of the possible maximum score. The most positive score would be 100% and the most negative score 0%. Overall, there was a very slight fall in enjoyment. However, there were interesting differences between the so-called 'gainers' and 'losers'.

Table 2-7: Changes in enjoyment of school

Period	All pupils%	Gainers%	Losers%
Before transfer	70.3	70.0	70.8
November of transfer year	75.4	76.6	72.8
June of transfer year	69.8	73.6	61.8*
N =	75	51	24

* Statistically significant at the 5% level. (Source: Galton and Willcocks, 1983)

The 'gainers' represented pupils identified as making academic progress during their first year after transfer, whereas 'losers' lost ground in the transfer year.

When pupils were grouped in this way there were indications that pupil enjoyment of school might be linked with their academic progress in some way. It is interesting to note that Galton and Willcocks observed that the attitudinal changes appeared to accompany the losses on the tests of basic skills rather than to precede them. This suggests that, as discussed on page 61, attitude does not necessarily precede achievement.

Two recent studies of transfer have also used questionnaires and again the findings suggest a small decline in favourable attitudes. Gross and Burdett (1996) observed that before transfer 81% of children were excited by the idea of transfer, and only 7% were unhappy or afraid. After transfer they say that 85% had settled well, suggesting that 15% had not settled well - a small increase in the proportion of children with unfavourable attitudes. This was a small study, involving 35 boys and 40 girls from three primary schools transferring to the same secondary school, and so these results may be unrepresentative of the wider society. However, they do correspond to the findings of Galton and Willcocks (1983), and are supported by later research, which found only a very slight decline in enjoyment on transfer (Huggins and Knight, 1997). These authors also found indications that boys enjoyed school less than girls, and observed distinct differences between classes and schools; they suggested that these differences might be related to differences in teaching methods. Again, this was a relatively small-scale study involving only four secondary schools and a sample of 51 girls and 55 boys.

To summarise: attitudes to school are generally very high when children are in their final year of primary school. Most children are looking forward to secondary school. After transfer there is a small decline in favourable attitudes, but for the great majority of children attitudes remain positive. Girls' attitudes to transfer appear to be more positive than those of boys.

2.4.3 CHANGES IN ATTITUDE TO SCIENCE ON TRANSFER

Only a small number of studies have investigated attitudes to science at the time of transfer to secondary school (Table 2-8), and only two longitudinal studies have been conducted since the introduction of the National Curriculum; both of these were qualitative studies, each involving only one school.

Table 2-8: UK studies investigating changes in attitudes to science at transfer

Date	Author	Country	Methods	Sample	Type
1994	Griffiths and Jones	England	Interviews	Not known	P
1998	Woodward and Woodward	Wales	Interviews	360	P
1993	Jarman	Northern Ireland	Essays	1767	R
1996	Sutherland, Johnston and Gardner	Northern Ireland	Interviews	~100	R
1980	Harvey and Edwards	England	Questionnaires	448	C
1981	Hadden	Scotland	Questionnaires	1000	L
1987	Craig	England	Questionnaires	342	L
1999	Campbell	England	Questionnaires & interviews	26	L
1998	Hawkey and Clay	England	Questionnaires	32	L

P=Prospective, R=Retrospective, C=Cross-sectional, L=Longitudinal.

2.4.3.1 PROSPECTIVE STUDIES

Studies of children's prospective attitudes to science just prior to transfer in the UK are rare, but two UK studies have examined children's expectations about secondary science at this time. Griffiths and Jones (1994) interviewed a small number of children during their last year at primary school. They noted that the children's experiences of science were mixed; the amount of hands-on practical work varied between classes and between schools (four primary schools were involved). The majority of these children looked forward to the transfer and they were excited at the prospect of secondary science.

These researchers observed that these children emphasised the more dramatic aspects of secondary science (whether factual or mythical), such as the dissection of bulls' eyes and frogs, the element of danger (fire, explosions), and the use of chemicals. They suggested that these children may have regarded the apparent 'theatricality' of secondary science as 'real' science as opposed to 'not real' primary science, and argued that such a perception made for a discontinuity between primary and secondary science. Furthermore, the interpretation of primary science as 'not real' reduces its value as a foundation, which may then be built on at secondary school.

Woodward & Woodward (1998) also used interviews. Children were asked to identify their favourite subject at primary school and then to say which subject they most looked forward to at secondary school. Science was not a popular subject at primary level (approximately 7% identified science as their favourite subject in 1993 and 1995) but it was identified as one of the most looked forward to at secondary school (approximately 14% naming science as the most looked forward to subject at secondary school). In their study a group of 120 children were interviewed in their final few weeks at primary school in 1991, 1993 and 1995, giving a total sample of 360, and over the four-year period of their research the observations did not change appreciably. The authors suggested three possible reasons for their results. These children might have perceived science as a 'new' subject because their participation (at primary school) may have been minimal, they may not have identified science activities as such in the primary school, or they may have been unconvinced of the authenticity of primary school science, (in other words they looked forward to secondary science because it was 'real science').

In summary: it would appear that children in their last year at primary school look forward to secondary science, but these children might not regard primary science as real science.

2.4.3.2 Retrospective studies

Two studies using mainly qualitative methods have provided some interesting insights into children's views of science after transfer. However, since both were conducted in Northern Ireland where a selective system operates, they might not be representative of the views of children in English schools.

Jarman (1993) worked with a sample of post-primary children, who towards the end of their first term at secondary school wrote about their experiences in science. In all, 900 girls and 867 boys were involved in this exercise, representing about 8% of the total population of first year post-primary pupils in Northern Ireland in the school year 1990/1991. The majority of pupils (82%) indicated that they had done science at primary school, and content analysis of the written comments of this group was used to investigate their views. Almost one-third of pupils recognised topics in secondary science as ones they had already met in primary school, and 27% of pupils reported similar or identical activities in primary and secondary science. These similarities did not seem to be a cause for concern among most pupils, for example:

> *We did about electric and we are doing about electricity here as well. We did about animals and we've done living things here. We did water there and we did water here. The science we did in primary school helped me here.* (Jarman, 1993, p 20).

Only one respondent is reported as finding this unsatisfactory, saying:

> *It's BORING!!!* (Op. cit., p 22).

Although similarities concentrated upon topics and activities, differences centred on equipment, practical work, teaching approach, difficulty, danger and the 'reality' of secondary science. Jarman observed that the different environment and equipment, together with the increased use of practical work were the most frequently mentioned differences. She was particularly impressed by the huge number mentioning equipment (63%), and the 'staggering 62%' who mentioned the bunsen burner, and she suggests that,

> *In the mind of the child, it seems, the act of lighting a bunsen burner assumes the status of a rite of passage into the realm of 'real' science.* (Op. cit.).

The increased depth of study was a feature of 20% of the comments and this was often associated with a perception of increased difficulty. Jarman observed that girls were more likely than boys to say that secondary science was harder than primary science, and that pupils in selective schools were more likely than those in non-selective schools to say that secondary school science was harder than primary science:

> [The] *survey provided evidence that some primary teachers adopted a less practical approach than did their secondary colleagues and that this influenced children's perceptions of the comparative 'reality' of science in the two sectors.* (Op. cit., p 28).

Jarman also noted that many children expressed their enjoyment of science in both sectors, but the only figure given in this paper is that 5% found that both primary and secondary school science were interesting/enjoyable.

In the second retrospective study, Sutherland et al (1996) carried out their research between 1994 and 1995; in all, twelve secondary schools and eighteen primary schools were involved. The schools were regarded as representative of those in Northern Ireland at that time, but did not constitute a random sample. At post-primary level interviews were carried out with 46 groups of pupils (4 groups from each of 11 schools and 2 groups from one school). Groups of between 4 and 6 pupils were interviewed, commonly five pupils in a group. Half of the pupil interviews dealt with English and Mathematics, and the other half with Science (in the pilot study, it was observed that pupils had more to say about science than about the other two subjects). Thus, somewhere between 92 and 138 children gave their views of science in this study.

Pupils were asked about their favourite and disliked aspects of subjects, the relative difficulty level of science in primary and post-primary school, and whether they had been told what science would be like at secondary school. Overall impressions were that secondary school science was mainly different from primary science. Only one group regarded it as essentially similar, and this was a group of pupils in a grammar school where the head of department had been identified as unusual in regarding the first year at secondary school as a progression from Key Stage 2. Typically pupils contrasted the more practical, experimental post-primary approach with what they saw as more didactic, rote-learning approach in primary school.

> *You do a lot more practical work now. In primary school you copied it all down off the blackboard* [Upper stream group, secondary high school]. (Op. cit., p 137)

Pupils appreciated the opportunity to be allowed to carry out experiments for themselves, rather than just watch teacher demonstrations:

> *Being allowed to do things on your own without the teacher always looking over your ...shoulder...all the time* (Op. cit. p.140)

In all, 19 groups agreed that they did more practical work at secondary school, or that they were doing it for the first time. There was also a sense that primary school had involved familiar domestic implements, and that these were somehow inferior to secondary school equipment:

> *In grammar school there are test tubes, Bunsen burners. In primary school it was just all home-made stuff like bits of wood with bits of cotton around it ...* (Op. cit. p.138)

Some children referred to previous experiments at primary school as 'wee things' and secondary school science as 'proper science'. Such comments may suggest that these pupils saw secondary science as a superior experience.

The teachers, who were interviewed, primary and post-primary had thought that repetition of work would be a problem for pupils, leading to some boredom. However, in contrast to mathematics where over three-quarters of the groups mentioned repetition of primary school work, only about one-third of the science groups spoke of topics that they had already covered at primary school. None of the groups indicated that they had dealt with familiar topics without significant progression. Only two pupils expressed boredom with secondary science, and they said they had not liked it at primary school either. There were mixed views about written work: some thought it was easier, others that it was harder. However, writing was one of the least enjoyed aspects of secondary science. Secondary school was also seen as 'harder' or more advanced, but usually regarded as rather exciting and quite challenging rather than as a cause of a difficult transition.

2.4.3.3 Cross-sectional studies

Cross-sectional studies make the assumption that the groups being compared will have the same characteristics and that it is therefore legitimate to make comparisons. However, unless the groups are carefully matched, or consist of random population samples this seems rather a large assumption to make. No UK studies meet these criteria and so studies from other countries must be considered instead. Such cross-sectional studies, involving children aged from 10 to 12 years old, find that children's attitudes to science are more positive when aged 10 to 11 years than when aged 11 to 12 years, in Israel for example, (Hofstein and Welch, 1984), and in the USA (Simpson & Oliver, 1985; Piburn & Baker, 1993; Arambula Greenfield, 1996). It must be borne in mind that attitudes to school decline on transfer and so attitudes to science would be expected to follow a similar trend.

2.4.3.4 LONGITUDINAL STUDIES

The few studies that have examined the change in attitude to science for the same children moving from primary school to secondary have found small changes in attitudes to some aspects of science across the transition.

Hadden (1981), in the only major UK longitudinal study of science attitudes on transfer, followed the changing attitudes of over 1000 pupils from fourteen primary schools as they moved to three secondary schools in Scotland. The study involved a comparison of children's attitudes to science with those towards geography and mathematics, from the last year of primary school to the second year of secondary school. In this study, Hadden reported a decline of children's generally positive attitudes to science over the years; more pronounced for girls than boys, but for science, attitudes remained more positive than for geography or mathematics. However, the decline was not regarded as major, as he stated in a subsequent paper:

> *During the first year of pupils' exposure to secondary school science, some erosion of initially highly polarised and favourable attitudes to science took place...but the evidence does not suggest that the erosion of interest has taken place to the extent that favourable attitudes to science... have become unfavourable attitudes.* (Hadden and Johnstone,1983, p.317)

This study pre-dated the ERA (1988) and occurred in the Scottish rather than the English educational system. Nevertheless, being the only large-scale longitudinal study of changing attitudes to science on transfer it is the best information available and is often quoted, (see for example, The Council for Science and Technology Report, 1998).

Hadden surveyed children from 14 primary schools with a range of socio-economic backgrounds, but these children transferred to only three secondary schools, and so the sample is unlikely to have been representative of Scottish schools. A particular problem with this survey is the lack of control of other influential variables; although attitudes to science were compared with those to mathematics and geography, attitudes to school were not taken into account, and the socio-economic backgrounds of the schools were not considered in the analysis. The common measurement scale used over the three-year period was that involving a small group of semantic differential statements.

Semantic differential statements, although widely used, had been the subject of some relevant criticism prior to Hadden's study, as the following comment illustrates:

> *Scottish 14 year olds showed some lack of comprehension, and a great deal of hostility towards the task'* [of using semantic differential statements] (Brown,1976, p.37).

Establishing the validity of the adjectives used in semantic differential statements is often difficult and does not appear to have been demonstrated in Hadden's study. No significant differences were found between boys and girls when the results of these semantic differential statements were compared. The reported difference between boys and girls was based on their answers to groups of Likert statements. Since the Likert statements were not identical from year to year, the reported changes cannot be strictly justified. In summary, this study, does not appear to have particular relevance in the wake of the 1988 Education Act and suffers from some methodological problems.

In an Australian study involving 516 pupils in twelve elementary schools moving to four Brisbane high schools analysis of variance and regression analysis were employed, offering control of some personal and classroom characteristics, although attitude to school was not included (Power, 1981). However, the sample was small, being composed of children from only four high schools in one city in Australia, and furthermore, despite making reference to social background as an important transfer issue, this does not appear to have been taken into consideration in the analysis. Since this research was conducted in Australian schools, over 20 years ago, it may not be comparable to the contemporary situation in the English system. Nonetheless, two of Power's main conclusions appear very similar to those of Hadden:

> *The attitude of boys towards science was consistently more positive than that of girls throughout the two-year period.* (Op. cit, p. 35)...
> *The results of this study provide some evidence indicating that there are no major problems confronting students on transition in the schools sampled so far as science is concerned. The majority of students enjoy science at both levels, and, contrary to popular belief, there is no sharp drop-off in student attitude as the year wears on.* (Op. cit., p.37)

Craig (1987) did not set out to study attitude change, but to investigate the differential effects of primary school experiences on <u>interest</u> in secondary science.

Interest in science and enjoyment of science are not synonymous, as Craig herself pointed out:

> *Interests refer to tendencies to seek out and participate in certain activities. Attitudes relate to tendencies to favour or reject particular groups of individuals, sets of ideas, or social institutions.* (Thorndyke and Hagen, 1969 quoted in Craig, 1987, p.81)

Craig was particularly interested in gender differences in science and found that interest in science on transfer dropped more for girls than for boys. She found no obvious relationships between the *amount* of primary science and attitudes to science at secondary school, and suggested that 'teaching style might be more important than the amount of science done' [at primary school]. This research pre-dated the 1988 Education Act, and the sample was quite small, involving nine primary schools and only two secondary schools, and although the secondary schools were from two neighbouring but separate LEAs, this could not be considered to be a representative sample. The analysis of the data involved simple comparisons of median values, no statistical tests were applied, and attitudes to school were not taken into consideration.

More recently, an Australian study (Speering & Rennie,1996) obtained results similar to those produced by Craig. The sample was relatively small and not random, involving 78 children from three primary schools in a middle-class area. Speering and Rennie, using a questionnaire, before and after transfer, asked about *interest in science* and also about *enjoyment of science.* The Australian research supports Craig's work, showing girls' *interest in science* falling more than boys' *interest* on transfer to secondary school. But, *enjoyment of science* falls less for girls than for boys.

However, there were some problems with this study. There is no mention of any control for attitude to school in connection with the questionnaire, and therefore it is difficult to know what effect was being observed. Furthermore, the use of a forcing, four-point scale for the Likert type questions may have reduced the reliability of the questionnaire (Foddy, 1993). The much larger sample size in the secondary school (147, compared with 78 in the primary schools) suggests that a comparison is being made between non-identical groups, again reducing its reliability.

The second part of Speering and Rennie's research involved case studies for 16 children. These children were all very positive about their secondary school experience, so for the case studies the school attitude variable was controlled. The children went to two different secondary schools and all were interviewed about halfway through their first year at secondary school. At this time, 6 of the 16 children liked science more, 3 liked it about the same and 7 liked it a lot less than at primary school. Positive attitudes were linked to enjoyment of practical work, and negative ones with note-taking and working from textbooks. A wide variety of teaching strategies were revealed, since, apart from 2 children in the same class, the remaining 14 all had different teachers. The children generally favoured the hands-on approach, and 13 out of the 16 were disappointed at the lack of student-teacher interaction.

The most recent studies into science attitudes on transfer use case study methodology with single classes of children. Campbell (1999) used questionnaires and interviews with one class in June and July of their last term in primary school, and again in December, as they came to the end of their first term in secondary school; in all, the responses from 26 pupils were used in analysis. These children expected the content at secondary school to be the same as that at primary school, but harder. In general they liked science because of the way it was taught rather than because of the content. In particular, the variety of activity and the personal autonomy were enjoyed. However, they had unrealistic expectations about learning science, looking forward to performing experiments with new and exciting equipment. More than half of these children stated that this was an unfulfilled expectation, as the comment from one boy illustrates:

> *I thought we would do a lot more experiments than we have done so far.*
> (Op. cit., 1999)

Secondary science was often viewed as better than primary science. When at primary school all but one respondent stated that they had enjoyed science; but when asked again at secondary level nearly half of the pupils said that they had not enjoyed primary science. The perception that better facilities and equipment were available at secondary school seemed to be associated with this change.

However, in contrast to Jarman's (1993) research, in this case study only one respondent at primary school mentioned the Bunsen burner. The authors also felt that there might be insufficient challenge during this first term at secondary school since only one pupil mentioned increased difficulty.

Hawkey & Clay (1999) used unstructured interviews, which were employed in year six, and repeated for a sub-set of the same children, in year seven.

The interviewer asked each child a standardised open-ended question, and in year seven the question was:

> *You have now spent a year at this school, since leaving primary school. In what ways have you found learning science to be:*
> *Different from the science learning you did in the primary school?*
> *Similar to the science learning you did in the primary school?*
> (Op. cit., 1998, p.81)

In each year the children's responses were found to focus on four issues: teachers, facilities, curriculum, and teaching and learning methods. Previous worries about strictness of teachers were not realised, and their specialist knowledge was appreciated. The facilities were regarded as *'better'*; and there was an emphasis on the use of *'real'* chemicals and *'Bunsen Burners'*. The curriculum was perceived as being similar to that in primary school, but differences in teaching and learning approach were also mentioned. There was an apparent contradiction between the *'done it before'* comments made by over half the children, and the view by almost all that science at secondary school was harder. However, no opinions were expressed specifically about enjoyment of science, and only one primary and one secondary school were involved.

It is evident from this review that longitudinal studies of science attitudes at transfer from primary to secondary school have been very limited. The quantitative research indicates that attitudes to science may become a little less positive after transfer, and that although before transfer attitudes may be more positive for boys' than for girls, after transfer the gap may be narrower. However, none of this work is recent, and only small, non-random numbers of schools were surveyed. The conclusions reached cannot be assumed to be representative of schools in England today. The qualitative research is more recent but offers little evidence about changes in attitude to science. However, these studies do demonstrate something of children's particular concerns about science at this stage; and they suggest that changes in teachers, teaching approaches, and facilities on transfer had positive effects on attitudes, but that increasing the difficulty of science might have a negative effect.

2.5 Summary

This Chapter has reviewed the research evidence concerned with attitudes to school, attitudes to science, and changes in these attitudes at transfer from primary to secondary school.

The majority of children appear to have very positive attitudes to school at both primary and secondary school. Age, gender, ethnicity and social background may be important influences, more favourable attitudes being associated with younger children, girls, children from ethnic minority groups, and children with higher socio-economic status (SES). Other possible influences relating to school variables, such as the school organisation and the teaching approach, have also been suggested.

At a personal level, the influences on attitudes to science are similar to those on attitudes to school and, apart from the influences associated with gender, they appear to operate in the same direction: variables related to more favourable attitudes to science are also related to more favourable attitudes to school. However, girls are generally more positive about school but less positive about science; and attitude to science and school both appear to decline as children grow older. Thus, the decline in positive attitudes to science may simply reflect a general decline in positive feelings about education, rather than a decline in enjoyment of science. Boys appear to be more positive than are girls about science, and societal factors may be involved in the development of these attitudes. Ethnic minority groups may have more positive attitudes to science, and lower SES is associated with less positive attitudes towards science. The evidence supports the view that the peer group has a strong effect on attitudes to science, and there is agreement that parental support for science activities has a positive effect on children's attitudes.

The school variables identified as being influential on pupil attitudes were the classroom environment and the teaching approach. The evidence indicates that open-ended laboratory activity, greater pupil autonomy and pupil-centred approaches in an organised classroom setting with clear, agreed rules have positive influences on pupil attitudes. The use of group work appears to have positive effects on attitudes, but children prefer to work in single-sex groups. Studies examining students' attitudes to science in relation to new curriculum or instructional materials comprise a large part of attitude research, but the results are not conclusive.

The teacher's understanding of science and confidence in the classroom were identified as being associated with children's attitudes to science. Teachers often lack sufficient subject content knowledge to teach effectively outside their own specialist area. Insufficient subject knowledge is often associated with less confidence in teaching, and this in turn has been linked with specific teaching strategies within the classroom. The research evidence concerning the influence of teachers' views about the Nature of Science is still open to question.

Before transfer children looked forward to new subjects, but at the same time they worried about the level of difficulty, and the amount of homework; girls hoped for more autonomy at secondary school. After transfer there was a small decline in favourable attitudes, but for the great majority of children attitudes remain positive. Girls' attitudes to transfer appear to be more positive than those of boys.

There have been few longitudinal studies of science attitudes at transfer from primary to secondary school, and no recent large-scale studies. The research indicates that attitudes to science may deteriorate slightly on transfer, but contrary to popular opinion there is no sharp decline. Girls were significantly more likely than boys to say that science was harder at secondary school, and boys' attitudes were usually more positive than those of girls. Positive attitudes were linked to enjoyment of practical work, and negative ones with note-taking and working from textbooks. Secondary science was often viewed as better and more 'real' than primary science. Although children were likely to say that secondary science was harder, this was more often seen as challenging rather than as a cause of a difficult transition.

Finally, there appear to be some methodological problems in attitudes to science research. In quantitative survey work there is often a lack of rigour in the selection of the sample: although some samples were large, the majority of pupils often came from a small number of schools within a single geographical area, samples were not usually random and some were simply convenience samples. It would not be possible to generalise on the basis of such sampling, and furthermore the results obtained are likely to suffer from bias. The statistical methods used sometimes appear to be inappropriate and simplistic, and there was often little or no control of variables; sometimes the only statistical tests used were simple bivariate correlations, which consider the effect of only one variable. Children's attitudes to science have been found to be closely linked with their attitudes to school, but this has not been taken into consideration in most of the research into attitudes to science. Many of the important variables believed to affect attitudes to science are also linked with attitudes to school, in particular gender, socio-economic background and ethnicity. Therefore, it is unclear whether the relationships mentioned in the literature derive from attitudes to science, from attitudes to school or from both. Finally, in the context of investigating changes in attitude, there appears to be little recognition of the fact that a cross-sectional study can only measure differences between groups and not changes; there have been few longitudinal studies of science attitudes at transfer from primary to secondary school.

A longitudinal approach, based in theory, which controls for attitudes to school, and allows for analysis of interacting variables, would appear to be necessary characteristics of a new study. In the next chapter, the aims of the current research study will be considered in the light of these methodological issues, and the other aspects raised by this review.

CHAPTER 3. APPROPRIATE METHODS AND THEORETICAL MODELS

This chapter is divided into two parts: in Part One, the rationale for the methodology will be argued by considering the research aims of the present study in the light of the methodological issues raised in the previous chapter, and in Part Two, the details of the chosen methods will be described.

Part 1. Issues in choosing an appropriate research method

The main questions that this research aims to investigate are as follows:

- Do pupils' attitudes to science change as they move from primary school to secondary school, and if so, can these changes be quantified?
- Are there differences in the attitudes and teaching style of primary and secondary school teachers to science teaching?
- If there are changes or differences in children's attitudes to science, what factors are associated with these?
- To what extent is any change in children's attitudes causally related to changes in teaching style?
- What measures might be taken to remove or lessen the adverse impact of any change in children's attitudes?

3.1.1 THEORETICAL PERSPECTIVES

The literature has indicated that studies of attitudes to science have often lacked a coherent theoretical perspective, and it is thought that the researcher's conceptions of the social world have direct effect on the choice of methodology (Cohen & Manion, 1994). At a fundamental level, researchers tend to hold to a particular epistemology, which influences their theoretical perspective, their methodology and choices of methods. Crotty (1998) has defined four distinct levels within the process of choosing an appropriate research method, which are represented in Table 3-1, below.

Table 3-1: The relationship between methods, methodology, and theoretical perspectives

Epistemology	Examples of theoretical perspectives	Examples of methodology	Examples of methods
Objectivism	Positivism (and post positivism)	Experimental research Survey research	Quantitative methods Sampling Measurement & scaling Questionnaire Statistical analysis Data reduction etc.
Constructionism	Interpretivism Symbolic interactionism Phenomenology Hermeneutics	Ethnography Phenomenological research	Case studies
Subjectivism (and its variants)	Critical enquiry Feminism Post-modernism etc.	Grounded theory Heuristic Enquiry Discourse analysis etc.	Qualitative methods Observation Interview Focus group Case study Life history Narrative etc.

Thus, the research presented here lies firmly outside the post-modernist paradigm as characterised by the purely local and contingent; the commitment to difference over identity (Fox, 2000); the relativity of truths rather than qualitative difference, and provisionality (Moore, 2000, p.30). However, going beyond the polarities in which different paradigms are frequently discussed, this work, based in realism, recognises complexity and difference and acknowledges that the researcher's tools and perspectives are not neutral; they come with their own biographical, social and historical baggage (Delamont, 2000).

To summarize these epistemologies: a realist (objectivist) believes that there is truth and meaning that is independent of social influence. A realist (objectivist) theory of knowledge takes as its starting point a belief that although knowledge is socially and historically constructed,

> *...the fact that all knowledge is social does not mean that all knowledge is epistemologically equal.* (Moore, 2000, p.31).

A constructionist takes the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. Idealists (subjectivists) generally believe in the relativity of truths, that knowledge is characterised by the purely local and contingent, the commitment to difference over identity (Fox, 2000).

Crotty suggests that researchers generally hold a particular epistemological position, and that their theoretical perspective is a consequence of this position. For example, a researcher with an objectivist view of the world might choose survey methodology and quantitative methods. However, Crotty also believes that methodological decisions may then arise either from theoretical perspectives, or from a practical choice of the best methods to meet the objectives. It is often suggested that the process of choosing the research method or methods involves selecting the most appropriate method for the objectives of the study. For example Giddens (1993) says,

> *A range of different research methods exist, and which is chosen depends on the overall objectives of the study, as well as the aspects of behaviour to be analysed. (Op. cit., p. 677).*

However, it is likely that both theoretical perspective and practical considerations will be involved in deciding on what is 'appropriate', and that this could lead to the use of mixed methods. Crotty's view is that mixing methods is acceptable as long as the researcher's theoretical perspective and/or epistemological position is clearly stated. Thus, the researcher may choose the most appropriate for the research objectives; but the researcher may also be drawn to a particular methodology because of strongly held philosophical beliefs, or because of a particular view concerning the value of theory.

Platt (1986) has questioned the link between theoretical position and methodology, finding little relationship between functionalism and the use of the survey; and Bryman (1988) suggests that,

> *...the contrast between quantitative and qualitative research in terms of verification of theory against preferring theory to emerge from the data is not as clear-cut as is sometimes implied.(* Op. cit., p. *98)*

Hammersley (1995) has also argued against the view that epistemology entirely determines the researcher's methods, and has suggested that researchers inherit methodology and philosophical assumptions.

> *... in large part we acquire the resources that make up our methodological orientation from others working in the field, and in this way we inherit both practical methods and philosophical assumptions simultaneously.*
> (Op. cit., p.4.)

In the case of research into attitudes to science most of the inherited methodology reflects an objectivist position. This is no doubt related in part to the fact that science educators, steeped in the traditions of empirical research, have done much of this research. But it is probable that Thurstone's statement that attitudes could be <u>measured</u> has also led to much quantitative work in this area. For example, the work of Haladyna et al (1982) and Crawley and Koballa (1994) suggest a positivist frame of reference, and are based on the premise that attitudes *can* be measured. However, some recent studies have used more subjective approaches, for example, Speering and Rennie (1996), Sutherland et al (1996), Hawkey & Clay (1998), have all worked with small groups of students, and have reached their conclusions by the interpretation of interviews.

So in summary, the choice of methodology is seen to depend in part upon the theoretical perspective of the researcher, but also upon what has been inherited from the research community. In the present study survey methodology has been selected partly because the researcher holds an objectivist view of the world, but also since the majority of studies in this area have used survey methodology, there are many resources available that can be built on. This latter point is essentially a practical one and leads into the next consideration: what methods are the most appropriate for this particular survey?

3.1.1.1 Choice of methods

Quantitative approaches share an underlying assumption that, to some extent, the behaviour of society can be observed and measured in the same way as naturally occurring phenomena are observed or measured, objectively, and using scientific methods. That is to say, a positivist, or empirical realist, position is assumed. From such a standpoint the methods and processes of natural science are regarded as being appropriate for the study of human behaviour. That people have feelings and give meaning to their lives through language, for example, is not regarded as an obstacle to the use of such methods. The philosophical paradigm of realism is often associated with this positivist view; there is a real world beyond the individual, which can be measured. A realist will usually take a deductive theoretical position, beginning with a theory or hypothesis which is then tested by a rigorous empirical examination and which must be rejected if the empirical evidence does not support it. Finally a realist believes that one should be objective and that one should suspend one's own personal beliefs and ideals and remain completely detached throughout an investigation whatever methods are used.

Quantitative methods tend to be most useful when a large sample is involved since they can give quick access to information not readily available by direct observation. For the policymaker, quantitative methods are often of more value than qualitative methods. The trends and patterns that can are drawn from such data can often be generalised to a population, and can inform decisions concerning overall practice.

Since the aims of the present research are to investigate general trends and patterns, then quantitative methods would seem to be most appropriate. However, a criticism often levelled at quantitative methodology is that of its reductionist nature. For example, the initial choices made about which questions are asked and which are left out may mean that certain areas of relevance are omitted, thus affecting the information obtained, and if a limited choice of responses are pre-defined then information may be lost. Although quantitative methods provide correlation information they cannot usually give causal data. On the other hand, qualitative methods may lead to causal data. Qualitative methods make the assumption that that the research is set in context and necessarily involves an examination of the language, actions or interactions of people. Such research is not concerned with measurement but instead looks for the meanings underlying actions or words. Bryman (1988) observed that,

> *The most fundamental characteristic of qualitative research is its express commitment to viewing events, actions, norms, values etc. from the perspective of the people who are being studied. (Op. cit.)*

The philosophical position of a committed qualitative researcher may be described as idealistic:

> *'Idealism ....argues that what exists is mind-dependent'* (Op. cit., p. 8).

Social and human realities are thought of as depending on the constituting activities of our minds. Further, the qualitative researcher's approach to theory is usually inductive rather than deductive, and as Cohen and Manion (1994) put it,

> ...[*interpretative researchers*] *begin with individuals and set out to understand their interpretation of the world around them. Theory is emergent and must arise from particular situations; it should be 'grounded' on data generated by the research act. Theory should not precede research but follow it.*
> (Op. cit., *p.37*).

Interpretativist researchers do not regard people as separate objects to be studied in a detached manner, and the methods and processes of natural science are therefore regarded as inappropriate. The researcher should not remain detached, but is seen as part of the research and must instead be able to see how he/she relates to the research and how he/she affects the research process; i.e. he/she must be reflexive throughout the research process.

Such methods can give in-depth pictures producing rich data. They relate to real life and may be the only way to study atypical behaviour, which occurs infrequently. Qualitative methods also have the great advantage of being readily accessible to the practitioner. The classroom teacher is able to read an account of classroom observations or interviews and gain immediate and useful insights from it. However, they also suffer from disadvantages. The very limited samples used restrict generalisation and may be biased. The methods are often unstructured, preventing replication and validation. If the relationship of the researcher and the subject of the research become too close then bias will be introduced as the researcher loses a sense of detachment. The methods also have practical disadvantages; unstructured interviews generally take considerably more time to conduct (and to analyse) than the structured interviews of quantitative research, and often require further visits.

3.1.1.2 Combining methods

The segregation of quantitative and qualitative methods, shown in Table 3.1 on page 137, has long been regarded by many as unnecessary; the view that methods should be combined so that they best meet the objectives of the study, was expressed in 1946 by Merton and Kendall as follows:

> *Social scientists have come to abandon the spurious choice between qualitative and quantitative data: they are concerned rather with that combination of both which makes use of the most valuable features of each. The problem becomes one of determining* <u>*at which points*</u> *they should adopt the one, and at which the other, approach?*
> (Op. cit., p.556)

More recently this position was restated by King, Keohane and Verba, (1994), who suggested that although there may appear to be very different types of research, which are based on different epistemological and philosophical standpoints in fact *these differences are mainly ones of style and specific technique.* (Op. cit., p.3)

Since every method has its advantages and disadvantages it would seem judicious to combine methods. In addition, the need for triangulation, by combining several methods within a single piece of research in order to supplement and check on each other is particularly appropriate when dealing with complex phenomena (Cohen & Manion, 1994).

Complicated social processes require examination of <u>all</u> the available data, and without an inclusive approach to data, important changes may be missed or not adequately understood; more data can lead to a better appreciation of complex topics (Ackroyd & Hughes, 1992). Moreover, in the context of science attitude research, Ormerod and Wood (1983) showed that different methods of investigating science attitudes produced results that were not highly correlated. They recommended that at least two different methods should be used in such an investigation.

Both qualitative and quantitative methods have problems of validity and reliability. A survey is affected by what is included and by what is left out, by the ways in which questions are worded and phrased, and by the contexts chosen. However, in any qualitative study the validity is affected by what is observed and by how the observations are interpreted. Ultimately, the results and the conclusions of any investigation are likely to be affected by the choices the researcher makes. However, methodological triangulation is an excellent way of improving both validity and reliability (Giddens, 1993; Cohen & Manion, 1994), and this is a strong argument for combining methods.

Since the aim of research should always be to understand and explain, no single view can be regarded as sufficient since different methods reflect different ways of understanding. Inevitably a combination of philosophical viewpoint, epistemological position and inherited practice and philosophy are brought to these different ways of knowing. Added to this is the recognition that triangulation of methods is necessary to overcome the disadvantages inherent in any one method. Therefore, to reach a fuller understanding of the research problem an inclusive approach should be taken. In the present study, quantitative attitude questionnaires that derive from earlier studies in this area, have been modified and used; but additionally, analysis of the written and interview responses of children and teachers have been used to provide triangulation and a better understanding of the questionnaire responses.

3.1.2 WHAT TYPE OF SURVEY?

3.1.2.1 LONGITUDINAL AND CROSS-SECTIONAL DESIGNS

There appears to be no consensus about a definition for longitudinal design, the only common denominator being *'variation of time and repeated observation of a given entity'* (Weinart & Schneider, 1993). However, it has been suggested that the only true longitudinal design is a prospective panel design where data are collected from the same cases at two or more distinct periods of time (Nesselroades and Baltes 1979). On the other hand, *'in pure cross-sectional research, measurement occurs once for each individual, subject, country or case in the study,'* (Menard,1991). In a cross -sectional study, different birth cohorts and hence different probability samples are taken from the same population and data are collected at the same time from these different samples. Consequently, although a longitudinal study *may* describe individual or group changes, a cross-sectional study *cannot* do so. For example, in a cross-sectional study of attitudes of children aged 10 and 12 years, it is possible to describe and compare the attitudes of the two groups. However, to suggest that any observed difference represents a change in attitude with age can only be an assumption, because two distinct groups are involved at the same time, and not one group at two different times. Thus, one of the main advantages of a longitudinal study is its ability to investigate change.

The value of longitudinal studies has been summarised by Bergman (1993):

> *Longitudinal studies are vital for studying individual development and cannot normally for this purpose be replaced by other kinds of studies. ... The main reason for using a longitudinal approach is really common sense: if you want to understand how an individual develops over time, you have to study the individual over time. All other approaches are more indirect and have to make questionable assumptions for the results to be applicable for statements about individual development. (Op. cit., p. 217)*

The longitudinal approach allows the investigation of *what* change occurs and also *how* and *why* such change occurs, whereas cross-sectional methods are inappropriate in causal research (Cohen & Manion, 1994).

Longitudinal studies are rarely undertaken, and this is probably because of the widely recognised problems of longitudinal research - the most obvious ones being the high cost, sample attrition and the conditioning that can occur after repeated measurements. However, the ability of a longitudinal study to establish temporal order, measure change and provide insights that would not be possible using cross-sectional methods (Arzi, 1988), may outweigh the disadvantages, many of which can be reduced with a carefully designed study.

It is often suggested that a longitudinal study is more costly than a cross-sectional one but this is not necessarily so (Menard, 1991) and the major cost is often one of time. The effects of attrition and repeated measures can be checked with reference to the first wave data and with an initially large random sample such effects can be minimised (Op. cit.).

However, an important factor, which must be taken into consideration when using a longitudinal approach is that the same instrument must be used each time, and that this instrument may change its meaning for the respondents over a period of time. It is therefore essential that the validity of the instruments are carefully checked on each occasion of use, for if the instruments change their meaning over time the data will suffer from 'response-shift bias' (Maxwell & Howard, 1981).

Therefore, a change in attitude to school science may occur for two reasons: either because the respondent's attitude to school science has actually changed, or because the meaning of the attitudinal object 'school science' used by the measuring instrument has changed for the respondent. However, if the meaning of the attitudinal object has changed then this implies a change in attitude; so in either case any resulting change is a measure of the subject's changed attitude. Therefore, although response-shift effects may be present they should not affect the outcome.

It has been suggested that longitudinal research must be defined both in terms of data and methods of data collection, and that quantitative methods must be used; as Menard says,

> *At a bare minimum, any truly longitudinal design would permit the measurement of difference or change.* (Op. cit., p.4.).

Nevertheless, valuable longitudinal studies have been made involving the collection of qualitative data, (see for example the study of the effects of transfer on individual children by Measor and Woods (1984).)

Theory is considered to be of particular relevance to longitudinal studies by Wienart and Schneider (1993). As they put it:

> *Longitudinal studies should generally be theoretically grounded and should allow specific hypotheses to be tested* (Op. cit. p.91)

And yet qualitative methods tend to rely less heavily on theoretical models, rather allowing theory to emerge from the data. However, Bergman (1993) suggests that if too rigid a model is proposed then effort might be wasted in pursuing the wrong path. Therefore, the use of qualitative methods does not appear to be precluded by choosing a longitudinal design.

3.1.2.2 Validity of longitudinal studies

Longitudinal studies offer better control for threats to external validity than do cross-sectional correlation studies and are sometimes described as 'quasi-experimental' (Sproull, 1995). The difference between a quasi-experimental and a true experimental study is that in a quasi-experimental study the treatment variable occurs naturally and is not introduced by the researcher. The best type of quasi-experimental study is a multiple time-series design, in which the subjects are randomly assigned to the treatment or control group and measurements are taken before and after treatment. Sometimes it is not possible to have a control group, and measurements are taken before and after the naturally occurring 'treatment' of one group; such a time-series design is acceptable when no better controlled design is feasible, and offers greater control than would a cross-sectional study. The present study involves measurements on a population of children before and after transfer to secondary school; a control group would be a matched sample who do not transfer to secondary school, but no such control group is available in the Essex school population.

On balance, a longitudinal design seems better suited to the examination of changes in attitude at transition than a cross-sectional design, since this would allow changes in individuals to be followed (Wienart & Schneider, 1993). (The relative values of cross-sectional and longitudinal approaches are discussed further with reference to the present data in Appendix 9).

3.1.2.3 THE MEASUREMENT OF CHANGE

Where quantitative methods have been used a longitudinal study will eventually yield at least two different sets of scores: scores after the first set of measures (Y1), and scores after the second set of measures (Y2). There are two ways to measure any change between Y1 and Y2. The first is to take the difference between A and B:

$Y2 - Y1 = X$ (where X is called the change score, the raw change or the raw gain).

A second way is to calculate the residual gain, using linear regression on variable Y1 to obtain a predicted or expected value leading to a second score (P). The expected value P is subtracted from the actual value of Y2 to give the residual gain:

$P - Y2 = Z$ (where Z is called the residual gain).

There has been some disagreement about the appropriateness of raw gain scores as measures of change because raw gain scores are systematically related to any random error of measurement, and they are typically less reliable than the scores on the variables from which they are calculated (Cronbach & Furby, 1970). Menard (1991) concludes that,

> *the decision to use any sort of measure of change in an analysis of change is not a simple issue, and may depend on the theoretical justification for using change measure....* (Op. cit., p.47)

However, Cronbach and Furby did propose a correction, which could be applied to the raw change scores, to improve their reliability. Moreover, Maxwell and Howard (1981) demonstrated that when the design is a multivariate, pre-test post-test with a large sample size and a large number of variables, then change scores can be used, without giving misleading results; Taris (2000) also takes this view. So, the use of raw scores appears to be appropriate in the present study.

3.1.3 Theory and hypotheses

In developing a model for this study three particular aspects of the literature were considered: existing models within the literature, which took account of influential variables, attitude theories, and techniques of attitude measurement.

3.1.3.1 Existing models

Influential statistical models were those developed by Peaker (1971), Keeves (1975), Haladyna et al (1982), and Schibeci (1989), and these will be considered first.

Peaker, used regression analysis and produced a path analysis model which indicated that the outcomes of secondary education were largely determined by events in primary school and pre-school, with a small contribution from home variables and school variables. Probably the most important aspect of this work was the development of a chronological model.

The model developed by Keeves considered the effects of the educational environment on attitudes and behaviour. Keeves' model assumed that the school environment was influenced by the societal system in which it was located, and that the individual within the school was also influenced by three distinct environmental situations: the home, the peer group and the school. Keeves also assumed that the variables would be chronologically related to each other as suggested by Peaker (Op. cit.)

Keeves identified three dimensions of educational environments: the structural, attitudinal and process dimensions. For example, structural dimensions of the home environment would include occupational status, income, and size of family. Structural dimensions of school environment would include school type, class size, and school size. Such variables were included because they were thought to exert an indirect influence. The attitudinal dimension included the objectives, attitudes and expectations of home, school and peers. The literature review of Chapter 2 has shown that these are likely to be important influences. Keeves regarded the process dimension as having the more direct influence and greater explanatory power. It includes the actions of parents, teachers and friends. Keeves makes the assumption that actions will have a more direct influence than status characteristics or expressed attitudes.

Using this model, Keeves found that initial achievement and attitudes, and the sex of student affected the attitudes and practices of the home, but that the attitudes and ambitions of parents contributed to final level of achievement. If home factors could be influenced then achievement should also be influenced. Structural characteristics of the classroom were also found to have an effect on achievement. Subject specialism was linked to achievement; achievement was greater when the teacher was teaching their specialist subject. The process dimension (interactions between student and teacher) were found to contribute to both achievement and attitude. The relationship between student and teacher was viewed as a reciprocal one; if a student has a good attitude (works hard, does what is asked, behaves well etc) then a higher level of affiliation with the teacher will develop which will lead to even better attitude and performance.

Haladyna et al (1982) distinguished between two types of variable, which they labelled as exogenous and endogenous. Exogenous variables were those located outside the institution of schooling and not under the direct control of the schooling process, and endogenous variables were those under the influence of the school process. Haladyna's model deals only with the classes of variables over which the educator has some influence, that is, the endogenous variables within the educational process: the student, the teacher and the learning environment. Two dimensions were hypothesised for these variables: content and focus. Haladyna et al maintained that nearly all studies of student attitudes could be classified into one of these two categories.

In the Haladyna model, student variables included any indicators that were attributable to the individual student but were not part of a larger context. Teacher variables were indicators that were unique to the individual science teacher. Learning environment variables were descriptive of the context and setting of the instructional programme, and could be described in terms of the variable's relationship to the organisation or institution being studied. However, temporal relationships were not considered.

Schibeci (1989) took Keeves' model as a starting point. Schibeci's model postulated a causal chain, which seeks to explain how students' achievement and attitude are influenced by both personal and non-personal variables. He assumed that variables on entry to secondary school would influence entry behaviours and attitudes. These entry behaviours and attitudes would in turn influence final outcomes in terms of behaviour and attitudes. The home, school and peer group were assumed to influence student behaviours at various points, not simply on entry to school. Path analysis suggested a strong relationship between initial and final achievement and between initial and final attitude, but only weak links between attitude and achievement.

This present research incorporates these ideas in making the following assumptions:

- There will be a temporal sequence, structural dimensions will precede attitudinal dimensions and a process dimension will follow attitudinal dimensions. (Peaker, 1971; Keeves, 1975).
- Antecedent conditions, such as level of interest and achievement at primary school, will precede those at secondary school. (Schibeci, 1989).
- Variables are of two types, exogenous (outside the control of the schooling process) and endogenous (under the control of the schooling process). (Haladyna et al, 1982).

Two arguments led to the inclusion in the model of certain variables and the exclusion of others. Firstly, school variables have been shown to have a considerable influence on attitudes to science, whereas there is less agreement about home, cultural and societal influences. The particular area of interest for this research is the transition from Key Stage 2 to Key Stage 3 of the National Curriculum, and at this point the most important change for an individual is likely to be that of the school and the teaching and learning environment. The issues of home background, gender and race are not ignored but are not the primary focus. Secondly, the present research aims to investigate factors that are likely to be of direct practical use to schools, and therefore focuses on school effects rather than home effects. Since the aim is to concentrate on the educational process the model concentrates on the endogenous variables. The lack of exogenous variables will reduce the explanatory power of the model, and it is expected that the model will not be able to take account of at least 40% of the variance. This figure is based on the findings of Keeves and others.

3.1.3.2 The role of Attitude theory

As discussed in Chapter 1, attitude theories have indicated that although attitudes and behaviour are linked it is unlikely that there will be a strong link between them unless a completely rational thought process is involved in determining the behaviour. The Heuristic Systematic Model (HSM) explains that that an individual may employ two modes of thought: systematic and heuristic. In systematic mode individuals make an effort to think carefully, but in Heuristic mode this does not happen. If a situation has little relevance or is difficult to understand then the individual is likely to use the Heuristic mode of thinking. Therefore, as in the models suggested by Keeves (1975), attitudes and achievement are assumed to follow parallel paths rather than a sequential one. Accordingly achievements are not included in the model.

3.1.3.3 Attitude measurement

The idea that an attitude is made up of many parts, which are integrated into an attitude structure (Chapter 1, page 54), gives rise to a view that attitudes should be regarded as multi-faceted; consequently any attitude measurement should combine many aspects of the attitude. The literature review in Chapter 2 has suggested that a variety of factors is likely to contribute to attitude to science, and so each of these factors should be taken into account when constructing any attitude measure. So any appropriate instrument should be able to measure a variety of different 'sub-attitudes', which could be regarded as the part of the attitude structure.

Multiple items should be used to measure each sub-attitude because there is no external way of verifying the responses in any attitude questionnaire. Such responses are generally sensitive to wording and contextual effects, so it is unwise to rely on single items. Furthermore, as Oppenheim (1992) has pointed out, vagaries of question wording will probably apply only to particular items, and thus will probably cancel out, whereas the underlying attitude will be common to all the items in a set or scale.

Thus, the measurement of attitude should test many different aspects of attitude to reach the underlying attitude structure, and should combine multiple measures to improve validity.

The review of attitude studies in Chapters 1 and 2 have indicated that there is a variety of possible methods for assessing attitudes. However, some of these methods were regarded as inappropriate for the measurement of children's attitudes in a naturalistic setting (for example, the use of lie detectors), and others depended upon a direct relationship between attitude and behaviour (for example, direct observation). Consequently only two possible approaches remained open: attitude questionnaires and projective tests. Although projective tests might yield good results they were ruled out for the following reasons:

- There is little existing material, and considerable time would be involved in the development of suitable materials.
- The interpretation of projective tests is also time-consuming, and the reliability and validity of the analyses are problematic.

On the other hand, the use of attitude questionnaires appeared to be appropriate because:

- There is much reliable and validated material already in existence.
- The use of such measures could allow multiple items to be combined.
- Numerical scoring systems have been devised and validated, thus allowing attitude scores to be incorporated into a statistical model.

3.1.3.4 Types of attitude scales

Attitude scales were originally devised by Thurstone (1928), but his original attitude measurement technique, although judged to be reliable and generally valid, has been criticised for its reliance on judges; and judges were shown to produce different scales if they held particularly pro- or anti- views on a particular issue. Caution is needed particularly when applying such scales cross-culturally. Thurstone scales are also very difficult and time-consuming to construct, and the most common attitude scales in present-day use are Likert scales and Osgood's Semantic Differential scales.

Likert scales correlate well with Thurstone scales, and they have been shown to be generally very reliable and as valid as Thurstone's original technique but not as time-consuming to construct (Himmelfarb, 1993). Indeed, the Likert method of scoring has been shown to be consistently more reliable than the Thurstone technique. Furthermore, a Likert scale with 20 to 25 items tends to yield a reliability of 0.90 or more, whereas when Thurstone's scales are used, typically twice as many items are needed to achieve the same level of reliability (Eiser, 1980).

Likert scales do not have built in dimensionality and so must be subjected to confirmatory factor analysis to ensure equivalence of items. When this is done the

Likert scale allows summated rating - addition of scores from several items, referring to the same construct, to produce a single score. This allows respondents to be rank ordered on the variables measured, (Sproull, 1995). This summative rating is particularly appropriate when multiple items are required to define a hypothetical construct such as attitude. It is difficult to say whether a

Likert scale yields an interval or an ordinal level of measurement. However, if a large sample is involved the scores do provide a ranking system (Oppenheim, 1992).

The semantic differential technique uses the individual's,

> *...reactions to stimulus words and concepts in terms of rating on bipolar scales defined with contrasting adjectives at each end* (Heise, 1970),

for example, *'good-bad'*. It has been described as *the attitude researcher's 'ever-ready batteries'* (Himmelfarb, 1993) because of its ease of use. Its use of adjectives that are very general means that specific belief items do not have to be prepared in advance. However, it is difficult to generate true bipolar adjectives, and both time and expertise are needed to develop adjectives that have not previously been tested. Another problem in choosing such adjectives is that they must be applicable and relevant to all measured constructs. Furthermore, it is difficult to know whether the measurement obtained should be regarded as an interval or an ordinal level. Also, it is unclear what properties the obtained scores have, and so the scores for individual items cannot be added. Despite these difficulties it is a widely used technique and most research into the technique supports its use (Sproull, 1995).

Likert scales were chosen for the present study rather than Semantic Differential scales because of their greater reliability and flexibility. As discussed above, in order to increase the reliability of attitude measurements it is necessary to produce multiple items, and the Likert technique permits the summation of multiple items. Identification of uni-dimensional items for the individual constructs, as Oppenheim (1992) points out, is a straightforward matter, when computer-aided factor analysis is used.

Attitude scales lack a real zero point, and this has led to considerable debate about whether attitude measurements should be treated as interval or ordinal measurements, and about whether non-parametric or parametric tests should be used in their analysis (Greene & D'Oliveira, 1982; Bryman & Cramer, 1994). Some authors have concluded that parametric tests should not be used with scales that lack interval properties (for example, Siegel, 1956; Greene & D'Oliveira, 1982), but others have argued that it is not the level of measurement that is the problem but the interpretation of certain statistical results (Himmelfarb, 1993). Davison & Sharma (1988 &1990) have shown that if standard assumptions of homogeneity of variance and normality hold (for a continuous ordinal variable) then many parametric tests, such as regression, one-way analysis of variance and t-tests, can be used, and that the conclusions drawn from these tests will apply to the underlying attitudes. This position is taken for granted in many current texts (see, for example, Kinnear and Gray, 2000).

If a sufficiently large sample is drawn from a population (that need not be normally distributed), the means of those samples will be normally distributed. In other words, most of the means will be very similar to that of the population although some of them will vary quite considerably. This proposition is known as the central limits theorem (see for example, Clarke & Cook, 1983), and means that for a large sample the standard assumptions of homogeneity of variance and normality will hold. Therefore, if a large sample is used then parametric tests, for example regression analysis, may be used in the analysis of the scores from Likert scales.

3.1.3.5 THE MODEL FOR THIS ANALYSIS.

Figures 3-1 to 3-2 on page 160 show the models to be used in analysis of the data from each year, and Figure 3-3 on page 161 shows the combined model to be used in analysis of the change data. The regression block number indicates the temporal order: block one is assumed to precede block two, block two precedes block three and so on.

Figure 3-1 Primary school model

REGRESSION BLOCKS					
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	Dependent variable
CHILD	SCHOOL	TEACHER	CLASSROOM	SCHOOL ATTITUDE	ATTITUDE TO SCIENCE Y6

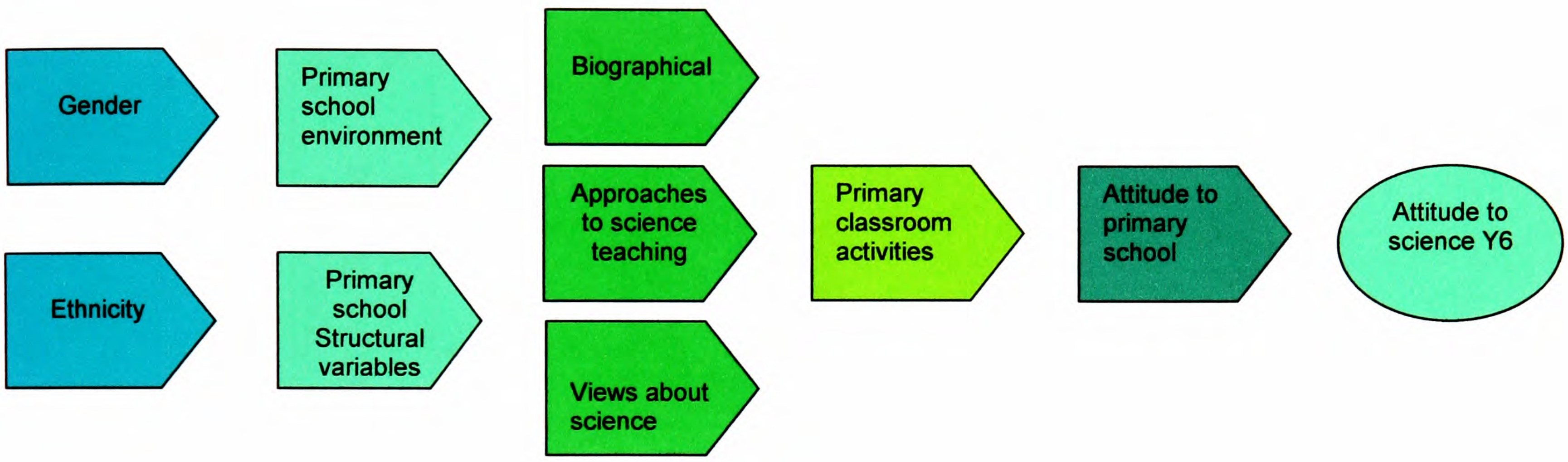


Figure 3-2: Secondary school model

REGRESSION BLOCKS					
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	Dependent variable
CHILD	SCHOOL	TEACHER	CLASSROOM	SCHOOL ATTITUDE	ATTITUDE TO SCIENCE Y7

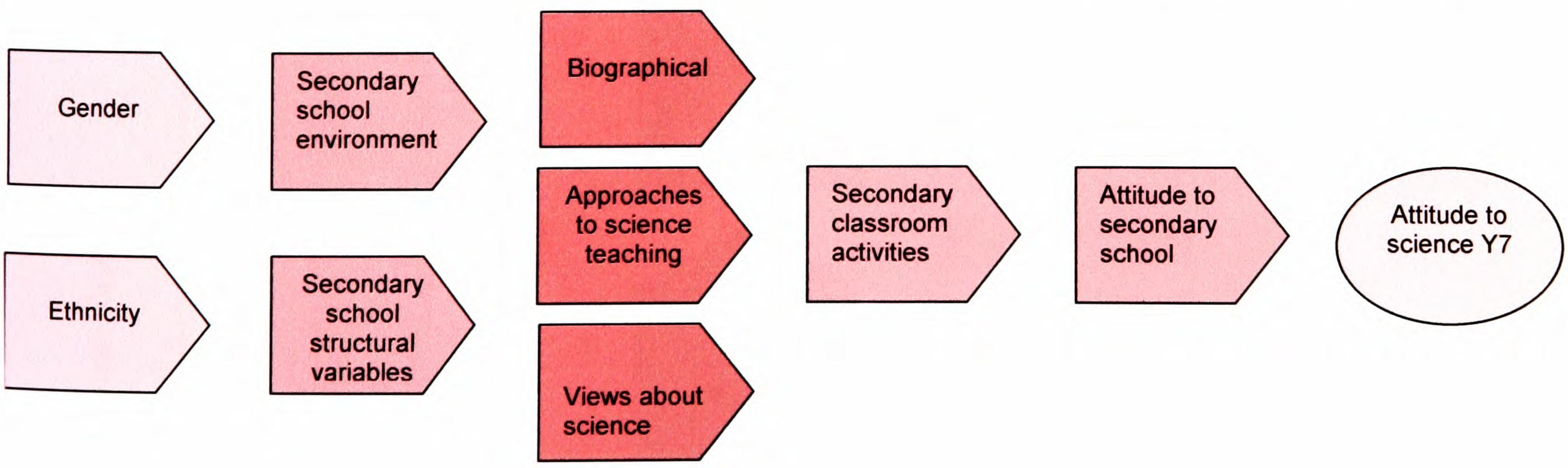
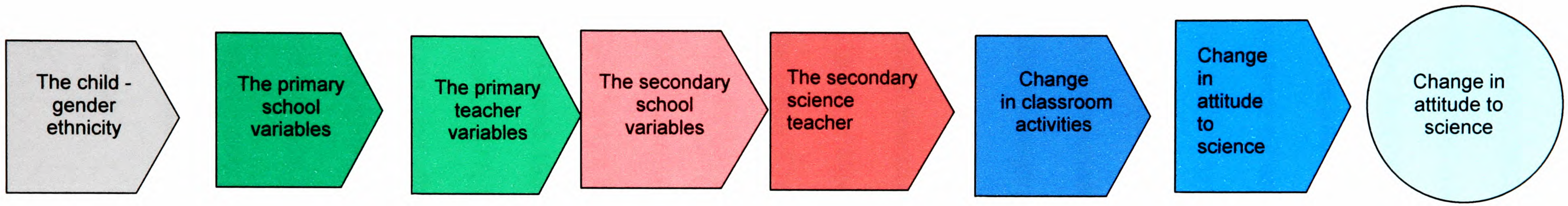


Figure3-3: Change model

REGRESSION BLOCKS							
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	BLOCK 6	BLOCK 7	Dependent variable
CHILD	PRIMARY SCHOOL VARIABLES	PRIMARY TEACHER VARIABLES	SECONDARY SCHOOL VARIABLES	SECONDARY TEACHER VARIABLES	CHANGE IN CLASSROOM ACTIVITIES	CHANGE IN ATTITUDE TO SCHOOL	CHANGE IN ATTITUDE TO SCIENCE



3.1.3.6 EXISTING INSTRUMENTS

3.1.3.6.1 Children's attitudes to science and school.

A survey of the literature revealed that a large number of multiple item Likert type instruments had been produced, but many of these were unsuitable. Either they did not examine the constructs required by the present study, or they originated in countries with educational systems different from that of England, so many of the items would lack meaning for children in English schools.

Two science attitude tests produced in 1970 and widely used are Skurnik & Jeffs' NFER Science Attitude Questionnaire, and the Scientific Attitude Inventory (SAI) (Moore & Sutman, 1970). However, the Skurnik and Jeffs questionnaire was criticised by Gardner (1975) because it contained items which did not reflect the construct that the scale set out to measure; and a critical review by Munby (1983) raised questions about the validity of Moore and Sutman's Scientific Attitudes Inventory. The Brunel Attitude Scale (Ormerod, 1976) focuses on attitudes to school science, but it was designed for 14 to 16 year old pupils in selective schools and often uses wording that might be inappropriate for 10-11 year-old children in today's schools. The Test of Science Related Attitude (TOSRA) was designed by Fraser (1977, 1978 and 1981) and validated with Australian children aged from 11 to 16 years (Fraser, 1977; Schibeci, and McGraw, 1981). It measures a variety of constructs, and offers well-validated and reliable scales. Another well-validated and reliable instrument was used in the Second International Mathematics and Science Study (SIMSS) (Keys et al, 1987). This questionnaire was designed specifically for the target population, English children aged from 10 to 14 years. These last two instruments appeared to be the most promising for the present research.

3.1.3.6.2 Teachers' attitudes to science and science teaching.

The importance of the classroom environment, and teachers' personal attitudes to science were discussed in Chapter 2 (pages 93 & 107). Three sorts of teacher data would be needed: some biographical detail, a measure of the importance of particular teaching approaches to the teacher, and information about the teacher's personal views of science. Since these data were to be included in the statistical model the measures to be used must lead to numerical scores. Again, Likert scales seemed most appropriate as the main measures.

The classroom approaches of teachers have more usually been determined by direct classroom observation, but there are problems with this method:

- Classroom observation of what a teacher does is not the same as what the teacher believes to be important.
- Classroom circumstances may affect the observations.
- In a large-scale study it would not be feasible to make classroom observations for all the teachers involved.

The literature revealed few studies of teaching approaches that relied on survey methods. Most work had been qualitative and based on classroom observation with small groups of teachers. Furthermore, studies had concentrated either on primary or on secondary teachers but none had tried to make comparisons between the two. Since no published scheme was thought appropriate it was decided to build scales by amalgamating ideas and items from relevant literature.

The work of Lantz and Kass (1987) used both qualitative and quantitative methods to investigate the important teaching approaches of secondary level chemistry teachers. Some of the values identified by Lantz & Kass also emerged from an investigation of primary teachers' ratings of the importance of various science teaching strategies (Tabron and Kerr,1971; Whittaker, 1976). These studies were used to guide the production of items about approaches to teaching.

Although a number of studies have looked at teachers' philosophical assumptions about the nature of science, none of them were ideal for the present study. Many were purely qualitative and worked with a very small number of teachers (for example, Lakin & Wellington, 1991 and 1994). Quantitative studies investigated either primary or secondary teachers' views, but no study was found which investigated the views of teachers in both sectors with the same instrument.

Nott and Wellington (1996), Koulaidis and Ogborn (1994 &1989), Loving (1991), Billeh & Malik (1977), and Kimball (1968) have all studied teachers' beliefs about the nature of science via questionnaires. The studies of Loving, Billeh & Malik, and Kimball were all designed for science specialists, and were deemed unsuitable for use with primary school teachers because they relied on testing knowledge of scientific concepts at a high level. The questionnaires produced by Koulaidis and Ogborn focused on the nature of scientific method and on the status of scientific knowledge. However, these were quite long and would be time-consuming to complete. It was recognised that teachers would have little time to spare, so the final survey would need to be as brief as possible and these two questionnaires were therefore rejected.

The 'Nature of science' profile designed by Nott and Wellington (1996) combined statements on a wide range of philosophical issues, relevant to science teaching in general, with a degree of brevity. However, the authors made no claims for its validity or reliability. But since this was the only suitable instrument available, it was decided to adapt this for the teachers' questionnaire, and check on the validity and reliability during piloting by means of interviews and factor analysis of the items (Lewis-Beck, 1994).

3.1.4 RELIABILITY AND VALIDITY

Reliability has been defined as *'the consistency or stability of a measure or test from one use to the next'* Vogt (1993), but such a definition is problematic when repeated measures are used to examine change. A more useful definition in this case is that reliability is the internal consistency of a set of items used for measuring a particular construct. Statistical tests are generally used to determine reliability, and the most frequently used index of internal consistency for a set of statements is Cronbach's α (Cramer,1998). This measure is used in the present study.

Validity may be categorised in two ways: as external or as internal. External validity is *'the ability to generalise the results of the research to populations, settings, treatment variables and measurement variables'* (Sproull, 1995) and is dependent on the sample size and sampling methods. Selecting a large sample improves external validity, but bias in samples poses a threat to validity, which can be reduced by randomising the sample. In the present study, sample validity was improved by increasing the number of schools participating and persuading some of those who had declined the initial invitation to be included.

Internal validity is the ability of an instrument to measures what it sets out to measure. Ambiguities, poor wording, and double negatives will affect the internal validity, so the most basic test of validity is the comprehensibility of the questionnaire. Internal validity itself has been defined in terms of four other categories of validity: construct, content, concurrent or predictive validity. Construct validity is tested using factor analysis; the test items should factor to give sets of uni-dimensional items, which represent single constructs. Content validity seeks to establish that the items are a well-balanced sample of the content domain to be measured. Concurrent validity shows that the test correlates well with other, well-validated measures of the same topic administered at about the same time, and predictive validity examines how well the test forecasts future criteria.

Each of these definitions deals with particular aspects of the measuring instrument, and each has its protagonists and its detractors. Oppenheim (1992), who discusses the use of attitude questionnaires in general, recommends the use of concurrent validity; but Gardener (1995 and 1996) believes that construct validity is particularly important in science attitude questionnaires. Bergman and Magnusson (1990) regard content validity and construct validity as equally good alternatives. In the present study, validity was tested in terms of construct validity using factor analysis, concurrent validity by reference to the results of other similar surveys, and content validity by interviews with children and teachers.

Although validity is improved by using the same measuring instruments or interviewers throughout, effects of testing and re-testing could be a problem. So for the present study, pilot studies were carried out with a sample similar to that of the target group; but the main study was conducted only with groups who were not involved in the pilot studies.

Using an experimental design and a control group can reduce threats to internal validity; but non-experimental designs do not include the highly controlled aspects of experimental designs, which allow the researcher to assume cause and effect. Thus the inferences, conclusions and recommendations of non-experimental research cannot be supported with as much confidence as in experimental research. When true experimental designs are not possible, time-series designs generally have better validity than do cross-sectional designs. Such a design is particularly useful for the study of institutions, such as schools where random assignment of subjects to experimental and control groups is usually not possible. In the present study, the event occurring (transfer) is regarded as the experimental treatment variable, and as the major historical event for the group during that time. If the sample is very large other less global events, within individual families, should not have a significant impact on the group changes occuring as a result of the transfer. The lack of a control group is problematic, but the use of an additional set of items about attitudes to school could be regarded as a control.

In order to follow individuals in a longitudinal study each individual is necessarily identified, and this might affect validity since lack of anonymity might reduce the truthfulness of responses. This problem was dealt with in the present study by giving written assurances of confidentiality, and by asking respondents to place their questionnaire into an envelope and to seal it immediately after completion of the questionnaire.

Finally, validity can be improved by checking on the first wave of data for differences between sample remaining and those lost, so that any changes as a result of attrition can be quantified.

3.1.5 THE VARIABLES TO BE INCLUDED IN THE QUESTIONNAIRES

3.1.5.1 CHILDREN'S QUESTIONNAIRE VARIABLES

The literature has indicated the importance of gender and ethnicity and so these two variables are included. Since attitude theory indicates that an underlying attitude will be made up of a number of sub-attitudes, several of the 'attitudes to science' constructs were incorporated into the pilot questionnaires. These were:

- Enjoyment and liking for school science
- Perception of the difficulty of school science
- Perception of the difficulty of written work
- Using calculations in science
- Enjoyment of practical work
- Perception of the importance of science to society
- Perception of the value of using computers in science
- Perception of the level of continuity and progression in science
- Scientific attitudes
- Views about the nature of science
- Importance of school science to future career.

Enjoyment of school and attitude to schoolwork items were also included because attitudes to school are thought to be associated with attitudes to science; and since the processes within the classroom may be an important influence on the individual attitude, a series of statements about classroom science activities were also included.

The literature suggested that the personality of the teacher may be an important influence, but this variable was not included for ethical and pragmatic reasons.

First, ethically, it seemed inappropriate to ask children to discuss their views of the teacher's personality and teaching ability since both children and teachers were identified by name throughout the process; secondly, pragmatically, teachers might have refused access if they felt that they might be directly criticised by the children.

3.1.5.2 Teachers' questionnaire variables

The construction of questionnaires for teachers was also directed by the literature and the variables included at the pilot stage are indicated below.

Teacher structural variables:

- Qualifications, levels and subjects
- Present responsibilities
- Previous work experience
- Length of service as a teacher

Teacher's age was not included since it seemed likely that the number of years of teaching experience and the nature and number of years of previous employment might be the more relevant factors.

Teacher attitudinal variables:

- Views on the relative importance of different approaches to teaching science
- Views about the nature of science.

3.1.5.3 School variables

School structural variables were:

- Size and type of school
- Percentage of free school meals taken in the school
- Percentage of children with special needs and statements
- Key Stage test results and GCSE results

School attitudinal variables related to transfer were:

- Views about liaison
- Views about the transfer of information

School process variables were:

- In primary school - teaching approach i.e. topic or subject based, classroom activities
- In secondary school - scheme of work, use of textbooks, approach (if stated), classroom activities.

Teacher and pupil attitudinal variables were investigated in two ways: by a written questionnaire to all pupils and teachers, and by interviews with a sample of pupils and teachers. School attitudinal variables were derived from interviews with science co-ordinators or head teachers in primary schools and with heads of science in secondary schools. Structural variables were obtained from three sources: the LEA handbooks, the 1991 census data for surrounding wards, and school league tables. Teacher variables were drawn from teachers' biographical questionnaires. Process variables were obtained from interviews with heads of science and science co-ordinators, and from the children's questionnaires.

3.2

Part 2. The practical details of the study

3.2.1 Introduction

The fieldwork for this study occurred in three consecutive stages: first pilot studies were conducted, after which the main study was initiated; this involved collecting data about pupils, teachers and schools, first in the primary schools, and then in the secondary schools. Figure 3-4 overleaf, gives the outline timetable for this work.

3.2.2 Pilot studies

The validity and reliability of the attitude questionnaires and interviews were established by means of pilot studies, the full details of which can be found in Appendix 1. In the case of the children's questionnaire two pilot studies were used: the first was designed to test the validity of using picture items as stimulus materials, and the second examined the validity and reliability of written items from existing measures. The children's questionnaires were tested with children of the same age and in similar locations as those of the target population.

Several pilot studies were made of potential instruments to be used with teachers. However, it was not possible to trial the teachers' questionnaire with the same teachers as those to be involved in the main study, since pre-test post-test effects might bias the outcomes. Therefore, the majority of the pilot tests were made with groups of pre-service teachers. The first pilot study was designed to check responses to the format and the constructs in each section, the second pilot study was used to further refine these two issues, and the third pilot was used to check on the validity and reliability of the final form of the questionnaire.

Figure 3-4: Timetable of the study

	Piloting		Main study: Phase 1 The Primary Schools			Main study: Phase 2 The Secondary schools		
	Children	Teachers	School data	Year 6 Children	Year 6 class teachers	School data	Year 7 Children	Secondary Science Teachers
March-95	Exploratory interviews	First pilot questionnaire						
April-95	First pilot questionnaire	Second pilot questionnaire						
May-95	Exploratory interviews	Third pilot questionnaire						
June-95	Second pilot questionnaire							
September-95			Interviews with Head teachers & Science Coordinators					
November-95				Questionnaire	Questionnaire			
February-96				Pilot interviews	Pilot interviews			
March-96/ April-96				Main interviews	Main interviews			
June-96						Interviews with Heads of Science		
February-97							Questionnaire	Questionnaire
March-97/ April-97							Interviews	Interviews

3.2.3 POPULATION AND SAMPLING

The ideal sample would have been a large probability sample from the population of all children in year six classes across the whole of England. This would have reduced the likelihood of bias, and it would have been more likely to yield representative results that could have been generalised to the whole population. However, problems of access, cost and time precluded the use of such a sample, and instead, the population of year six children from a representative sample of Essex schools was used. Cost was the main obstacle since face-to-face interviews were part of the research design. The cost of such interviews in terms of time and travel if a random sample of the population of England was used was regarded as prohibitive. Hence, Essex was the target instead, and this allowed the possibility of as many personal visits as were felt necessary without cost becoming a problem. Also, as Bryman and Cramer (1994) have pointed out, the use of probability selection methods will not necessarily lead to better representation than some non-random samples when factors such as access and non-response are considered.

But Essex was considered to be representative of England as a whole, and for the following reasons (see Appendix 2 for full statistics):

- The Essex local education authority (LEA) is one of the largest in England, geographically and in terms of pupils on roll; only Hampshire and Kent are larger.
- The average performance of Essex pupils in National tests, is very close to the National averages, and overall is a better representation of the mean values than either, say, Hampshire or Kent.

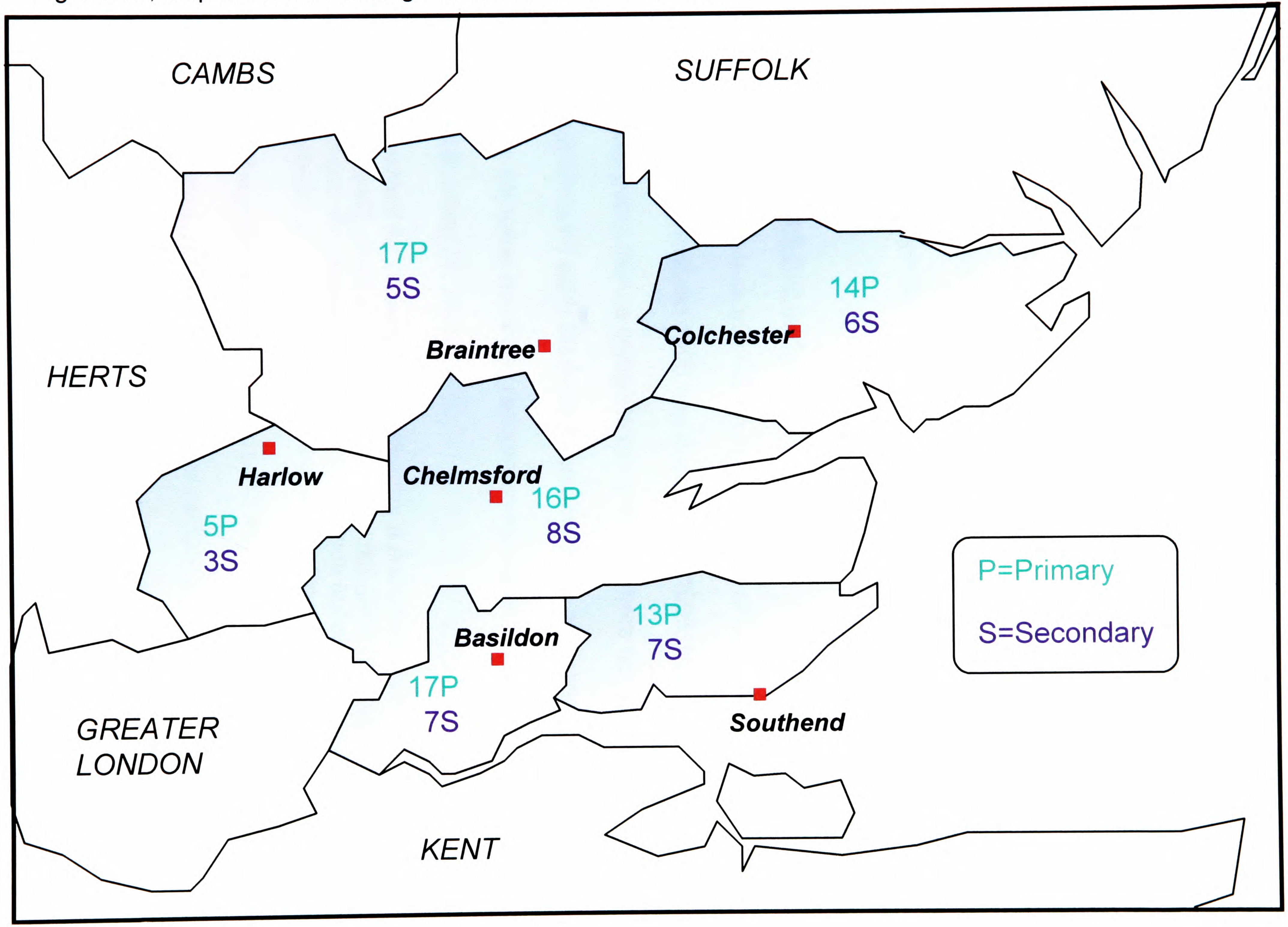
- In terms of GCSE examination results and Key Stage three performance tests Essex also falls very close to the mean for England.
- Having such a large geographical LEA ensures that a wide variety of communities can be sampled: Essex has county borders with London and with rural Suffolk and also includes some isolated communities at the edge of the North Sea. (See Figure 3-5, overleaf).

However, Essex is not representative of England, in three ways (see Appendix 2 for figures):

- Essex has not fully embraced the comprehensive system and so, as well as having a large number of comprehensive schools, it also includes a group of Grammar and Secondary Modern schools. Thus, a representative sample of Essex schools will contain comprehensive, Grammar and Secondary Modern schools.
- An unusually large number of Essex schools are Grant Maintained (GM), both at primary and secondary level, and so the sample will contain a larger proportion of GM schools than is found in the total population of schools in England.
- The figures from the National Census of 1991 reveals some differences between Essex and National social norms, in particular ethnic minority groups are under represented.

So, Essex has many characteristics, which makes it a suitable county to study in place of a National sample, but the high proportion of selective and GM schools, and the under-representation of ethnic minority groups in Essex may need to be taken into consideration when interpreting the results of the study

Figure 3-5; Map of Essex showing the number & area of schools in the survey



3.2.3.1 SAMPLING CONSTRAINTS

3.2.3.1.1 Longitudinal design

The research design required that the same children were surveyed in each year of the study; therefore, it was essential that the children from the sample of primary schools were represented the following year in the sample of secondary schools. This constrained the selection of the sample of both primary schools and secondary schools. Thus, some secondary schools that were keen to take part had to be excluded from the main study when no feeder primary school would participate, and vice versa. These schools were invited to take part in the pilot studies instead.

3.2.3.1.2 The sampling frame and random sampling

The target population was all children in the County of Essex whose tenth birthday fell between September 1st 1995 and August 30th 1996. In order to take a random sample of this population, a complete list of its members would have been required, but since no such list existed, an alternative sampling approach was used. Cluster sampling has been recommended under these circumstances, and is described by Vogt (1993) as,

> *...a method for drawing a sample from a population in two or more stages. It is typically used when researchers cannot get a complete list of the members of a population they wish to study but can get a complete list of the groups or 'clusters' of the population.* (Op. cit. p.37)

In this study the schools are the clusters. All the members of the population of each cluster are used in one-stage cluster sampling, and this reduces the sampling error, which increases at each stage. Cluster sampling, where a specific number of schools are selected randomly from the whole population of schools, is an acceptable method where the sample size is large (Vogt, 1993); and it is better to have a larger sample since the sampling error is reduced as the sample size increases. As indicated, in this case the 'clusters' were the schools in Essex, and these were listed in full (Essex County Council, 1994/1995a and 1995).[1] Within each selected school, all the individual children in the year six and seven classes, who were not absent, were surveyed. So, at this level the sampling was random in that every member of the cluster had an equal probability of being included.

3.2.3.1.3 Geography

As described above, Essex is a very large County with a diversity of environments, and if a simple random cluster sample had been used this diversity would not have been taken into account. It was therefore, decided to take a representative sample of clusters. Essex is divided into six administrative areas and within each area the schools are listed under the nearest large town. A minimum of one school was selected from each town, and where the list indicated different types of school within a single town, one school was selected to represent each type. In very large towns where there were a number of schools of the same type, the largest and the smallest of these schools were selected. The primary schools were selected as follows: if many of the children from a particular primary school usually transferred to one of the selected secondary schools then the primary school was also selected.[2] The school types and percentages selected and those included in the final sample are indicated in Tables 3-2 to 3-5 below.

[1] Even these lists did not include *all* members of the population of interest since it did not include private schools. However, the Grammar schools included a high proportion of children from private schools, and thus the secondary school sample contained a proportion of children from private schools. At primary level, one private school from Essex, where the researcher was known, agreed to take part.

[2] The information about relationships between schools was obtained by telephone conversations with staff in each of the area offices.

Table 3-2: Types of primary schools in Essex

School type	LEA	GM	Church	Primary	Junior
Number in Essex	390	64	137	336	118
Number contacted	177	34	42	139	72
Number agreeing to survey	65	15	15	50	30
% of Essex schools surveyed	16.7	23.4	11.0	14.9	25.4
% of contacted schools surveyed	36.7	44.1	35.7	36.0	41.7

Table 3-3:Types of secondary school in Essex

School type	LEA	GM	Modern	Grammar	Comprehensive	RC or Segregated comprehensive
Number in Essex	34	69	4	8	83	8
Number contacted	19	50	3	5	61	2
Number agreeing to survey	11	24	1	2	31	1
% of all Essex schools surveyed	32.4	34.8	25.0	25.0	37.3	12.5
% of contacted schools surveyed	57.9	48.0	33.3	40.0	50.8	50.0

Table 3-4: Primary schools: details of survey numbers

Essex area	Total number of schools	Number of schools contacted	Number of schools agreeing to participate	Percentage of schools agreeing to participate
North west	88	36	17	19.32
North east	104	26	14	13.46
Mid	103	33	16	15.53
West	75	27	5	6.67
South west	112	46	16	14.3
South east	96	43	12	12.5
All areas	578	211	80	13.8

Table 3-5: Secondary schools: details of survey numbers

Essex area	Total number of schools	Number of schools contacted	Number of schools agreeing to participate	Percentage of schools agreeing to participate
North west	12	10	5	41.67
North east	17	8	6	35.29
Mid	19	9	8	42.11
West	11	7	3	27.27
South west	21	18	6	28.6
South east	23	17	7	30.43
All areas	103	69	35	34.0

N.B. One primary school and one secondary school withdrew after receiving the survey data, and one secondary school withdrew after agreeing to take part because of pressure of work.

3.2.3.1.4 <u>Access</u>

Although a representative sample of the schools in Essex was invited to participate, some declined all invitations, and had to be left out of the design sample. The survey does not include any children from Roman Catholic schools since none of those approached would participate, and children from independent fee-paying schools were not fully represented.

A letter of invitation to participate, setting out the aims of the research, together with an outline of what would be involved, was sent to all selected schools. The literature suggested that a response rate in the region of 60% would be reasonable for an initial postal contact (Hague, 1993), and since schools replying might accept or decline the invitation to participate, the proportion of positive responses might be as low as 30% of the original sample. So letters were sent to three times as many schools as were required for the final sample.

Initially, the response rate was 47% with 20% agreeing to take part in the study. Some of the positive responses were from secondary schools to which there were no linking primary schools, and vice versa. So, the first follow-up was by telephone to all the schools which had not replied, *and* where either the secondary or primary linking/feeder schools had already agreed to be involved. After the telephone calls a second letter was sent out to every school that had not given a definite "no". At this stage, there was still some under-representation in certain areas, and further telephone calls and letters were used to try to achieve better representation. This applied in particular to the West Essex region and also to Grammar, Secondary Modern and Roman Catholic schools. Attempts were made to include at least one private school at primary and secondary level, and letters and telephone calls were again used, as described above. The final sample is representative of grammar and secondary modern schools, but only one private school and no Roman Catholic schools are included.

There is some under-representation in the West Essex region, and this may be because much of this region borders the London Borough of Epping.

Schools in this region perceive themselves as having more in common with London than with Essex, and the initial contact letter described the study as an Essex study. Some confirmation of this view was obtained in telephone conversations with schools in this region when attempts were made to gain access at the follow-up stage. The atypical nature of the region is emphasised by the fact that the only identifiable town is Harlow.

3.2.3.2 SAMPLE SIZE AND CONSTITUTION

Where the standard deviation of the population is unknown, the formula used to calculate the required sample size is:

$n = (z^2 * s^2)/ e^2$ (Sproull,1995, p125)

where:

z = the number of standard errors for a specified confidence level

e = tolerable error specified by researcher

s = sample Standard Deviation (from pilot sample)

In the present study:

z = 1.96 (95% confidence level)	
s = 1.29	
If e = 0.05	And if e = 0.06
then: n = 2557	then: n = 1776

The average class size in Essex primary schools in 1995 was 26.57 (Essex County Council, 1995b), therefore the approximate number of participating classes required would be:

either	2557/26.57 = 96	or	1776/26.57 = 67

The majority of primary schools in Essex had between 1 and 3 year six classes, and so the minimum number of primary schools required would be 23 and the maximum 96. Since not all children in one class will transfer to the same secondary school, more than the minimum number of schools would be required.

Sample mortality is a well-known problem of longitudinal studies, so an initial sample, with at least 3000 children, would be needed to ensure that the final sample would be sufficiently large as to minimise measurement errors.

In their final year in primary school, 3987 children from 80 primary schools were surveyed. This represents 22.8% of the total population of 17469 school children of age 10-11 in Essex.

3.2.4 The measurement instruments

3.2.4.1 The children's questionnaire

The children's questionnaire took the form of a 4-page booklet containing 47 Likert-style items, with six response categories (see Appendix 3). Response choices ranged from "strongly agree" to "strongly disagree", with a "don't know" box at the end. There was also a free response section at the end asking for children's views about secondary school science. The questionnaire utilised some items from the International Schools Association for the Evaluation of Educational Achievement (Keys, 1987), and other items were developed from the pilot studies, as described in Appendix 1. Teachers were asked to read the questionnaire through with the children, and the children were asked to put a tick in the box that most closely matched their feelings about each item.

3.2.4.2 Children's interviews

Interviews were used to help to validate the questionnaire, to check on assumptions made and to look at the context. Selection for interview was based on the results of the questionnaire: children in year six were selected if the results of their questionnaire suggested that, either they were very positive or very negative about science. In year six 120 children, from 20 primary and junior schools, were selected, and as many as possible of the same children were interviewed again a year later after transfer to secondary school (57 in all). All interviews were tape-recorded (with permission from the children) for later transcription, and some notes were taken during the interviews.

Semi-structured interviews evolved partly from the analysis of the questionnaire data, and respondents were selected on the basis of their scores on the 'enjoyment of science' scale. During the interview the respondent's enjoyment of science was discussed, for later comparison with their attitude 'score'. Analysis of the questionnaire data indicated strong correlations between attitude to science lessons, and written work, practical work and the perceived difficulty of science. The children were asked for their views about these aspects of science during the interview to clarify these relationships. The second focus of the interview at primary school was the child's image of secondary school science, and at secondary school, the child's comparison of primary and secondary science. The interview schedule was drawn up bearing these issues in mind. (A copy of the interview schedules used with years 6 and 7 can be found in Appendix 3.)

The choice of using group or individual interviews was made after considering the advantages and disadvantages of each method discussed in the literature and after practical experience in the pilot studies. The group interview suffers from the disadvantage that the children's responses are unlikely to be independent, and might be influenced by the presence of other members of the peer group. On the other hand, interactions between children might lead to wider range of responses.

As Cohen and Manion (1994) put it,

> *...10-year olds' understanding of severe learning difficulties was enhanced in group interview situations.* (Op. cit., p. 287).

Furthermore, the pilot study revealed that the children spoke more freely when in a group than when in a one-to-one situation with the interviewer. There are also practical and organisational advantages to the group interview: it is less disruptive of teaching time if a group of children are extracted from a class at the same time, and in view of present-day concerns about child abuse it is often advisable to interview groups rather than individuals. The procedure varied slightly from school to school and depended on the preferences and advice of the individual class teacher; typically children were interviewed in pairs but on a few occasions children were interviewed individually. Those occasions were either because the close friend who should have been present was absent from school on the interview day, or because the class teacher insisted that the child would speak more freely if interviewed alone.

Every effort was made to reduce bias; questioning was kept to a minimum and leading questions were avoided. All interviews were conducted in a private room and confidentiality was stressed. Drinks and biscuits were provided to create a more informal atmosphere and most children responded favourably to the experience, the vast majority relaxing fairly rapidly. The reasons for the interviews were explained simply, and all respondents were asked for their permission to undertake an interview and to tape-record the interviews.

3.2.4.3 Teachers' Questionnaires

The teachers' questionnaire was constructed in three sections: biographical details, preferred teaching approach and views about the nature of science.

The teaching approach section consisted of 14 statements about possible approaches and offered 4 choices of response: very important, quite important, not important and irrelevant. Teachers' views about the nature of science consisted of 21 Likert-style items, with six response categories. Response choices ranged from "strongly agree" to "strongly disagree" with a "don't know" box at the end. Free response items were included at the end of sections 2 and 3. (A copy of the questionnaire is included in Appendix 3). This questionnaire was sent to all the primary class teachers and all the secondary science teachers of the children involved in the surveys, with an accompanying letter explaining the reasons for the survey and asking for their help. Envelopes were provided for the teachers to return the questionnaires. A second letter was sent to teachers who did not reply, explaining the importance of their making a response and stressing confidentiality. The first replies were compared with late replies and there was no significant difference in distribution of responses.

3.2.4.4 Teachers' interviews

Two types of interviews were carried out as part of the main study: interviews to collect factual information about the schools involved, and interviews to validate the teachers' questionnaires.

Factual data collection interviews were carried out with Head Teachers or science co-ordinators in primary schools and with Heads of science in secondary schools. These structured interviews took place in every school involved in the main study, before the surveys were carried out. The interviews were used to obtain information about teaching methods and schemes of work in science, assessment arrangements, primary/secondary liaison programmes, and pupil ethnicity. Responses were recorded in note-form on the interview schedule sheet as the interviews proceeded. (Copies of the primary and secondary schedules can be found in Appendix 3.)

Interviews designed to validate the teachers' questionnaires were carried out with the teachers of children who had been interviewed. This involved interviews with 34 primary teachers and 30 secondary school teachers. These interviews were tape-recorded for later transcription, and notes were made after the interviews. The interviews were semi-structured with questions focusing on similar issues to those found in the teachers' questionnaire. (A copy of the interview schedule can also be found in Appendix 3.)

Efforts were made to reduce interview bias by keeping the interviewer's questioning to a minimum and trying to avoid leading questions. The reasons behind the interviews and the research were explained, any other questions that the teacher wanted to ask were answered as fully as possible, every teacher was given assurances of confidentiality, and the interviews were conducted in a quiet and usually private place. However, in some primary schools where space was limited, interviews were occasionally conducted in the staff room where other members of staff passed through from time to time. The respondents were given the opportunity to stop the interview when this happened, but none of them asked to stop and none seemed concerned at being overheard. Permission was sought to tape-record interviews; only one teacher was unhappy about this, and in that case full notes were made after the interview.

3.2.5 DATA ANALYSIS

3.2.5.1 DATA FROM THE CHILDREN'S QUESTIONNAIRES

The statistical methods used in the present study were dictated by the sample size and the number of variables involved. Parametric tests were used for all analysis of the children's data because large samples and multiple variables were involved.

Initially, simple descriptive methods were used to produce, for example, frequency tables, mean scores, and standard deviations. Next, chi squared tests and correlation coefficients (Pearson's product moment correlation and partial correlation coefficients) were calculated to look for significantly related variable. (For details of these tests see, for example, Daly et al, 1995). Pearson's product moment correlations between the criterion measure, attitude to science, and each of the other measures were calculated. This procedure provided initial estimations of the strength of association between individual variables. Partial correlation coefficients were calculated to establish the effects of controlling for attitudes to school. However, since many of the predictor variables were expected to be associated with each other, this approach was unlikely to provide a reliable estimate of the relative importance of the predictor variables in explaining the students' enjoyment of science. Although the use of partial correlation coefficients is one way in which multivariate analysis of relationships is conducted, it is not normally extended to more than three other variables. In the present study a large number of variables were measured, relating to the child, the school, the teacher as well as to classroom activities and school attitudes. Where large numbers of variables are involved multiple regression is more appropriate (Bryman & Cramer, 1994). Consequently, the last stage of the analysis involved the use of multiple regression analysis. Multiple regression analysis is used to determine which variables are most strongly related to the criterion, (i.e. attitude to science), and also to examine how much of the variance of attitude to science is explained by each of these variables. (Cramer, 1998).

Certain assumptions were made about the way in which the predictor measures are related to each other and to the attitude to science criterion, following the methods used in the SIMMS study (Keys, 1987). The models described on pages 160 and 161 assume that the measures used were chronologically related to each other. This assumption governed the order of precedence given to five broad groups of predictor variables included in the regression analysis. Home factors (not measured in this study) were assumed to precede all student variables, which in turn were assumed to precede school variables. School variables were assumed to precede teacher variables. All year 6 variables were assumed to precede all year 7 variables. The blocks were then entered into each of the regression analyses in the following order:

1. student variables
2. the primary school
3. the primary teachers
4. the secondary school
5. the secondary teachers

Each attitude to science measure was the subject of a separate regression analysis.

3.2.5.2 Data from the teachers' questionnaires

A separate analysis of the teachers' data was undertaken in order to investigate teachers' attitudes to science and to look for associations between teacher variables. The primary and secondary teachers' data were analysed separately to look for associations between variables, using correlation coefficients. Similarities and differences between the responses of the two groups of teachers were investigated using either parametric or non-parametric tests, depending on the nature of the data. For continuous data, t-tests and Pearson's correlation coefficients were used but where data was purely categorical, association was examined by means of chi squared tests and differences by Mann-Whitney tests. Where there appeared to be the possibility of interaction between a number of variables, analysis of variance techniques were used (e.g. Daly et al, 1995).

3.2.6 Written free response data

A maximum of 4000 written responses were anticipated, and so the aim of the analysis was to build up a picture of what was important to these children through content analysis of simple data. Accordingly, children were asked to make lists rather than to write in full sentences.

The NUD.IST computer software was used to assist the process of coding and analysing (Richards and Richards, 1991a and 1991b; Fielding and Lee, 1998). Coding procedures, memo writing and diagramming were used as data analysis strategies. Three types of coding were used: open coding, axial coding and selective coding. Initially the process of Open Coding was used to break down the raw data into simple categories. This involved examining the nature of the data, comparing, conceptualizing and forming categories and sub-categories.

The NUD.IST software is *'particularly useful for the development of hierarchical networks of categories'* (Kelle, Prein, & Bird, 1995). Axial Coding follows Open Coding, and puts the data back together again in new ways by establishing relationships between categories and sub-categories. Finally, Selective Coding will be used for theory building. Selective coding is the process of 'integrating and refining categories' (Strauss and Corbin, 1998, p143); it is the process by which data becomes theory. NUD.IST software provides a hierarchical 'tree display' window, which,

> *...helps the researcher manage a large database with visual clarity and to track the categories that emerge* (Fetterman, 1998, p 98)

Triangulation is continued throughout the data analysis, through the use of matrices, which provide a means of cross-referencing categories with the macro conditions/consequences.

3.2.7 INTERVIEW DATA

Interviews (children and teachers) were used initially to validate the questionnaire and so at the first stage no in-depth analysis was made. The notes taken during interviews were compared with the data from the questionnaires. It is intended to use the transcripts of these interviews in further work resulting from the conclusions of this study, but lack of time prevented any further analysis at this stage.

CHAPTER 4. YEAR 6 AND YEAR 7: RESULTS AND COMPARISONS

4.1 Introduction

The aim of this chapter is to present and compare the data obtained from the children at primary and secondary level, from their schools, and from teachers in their schools. The data from within each group (children, teachers and schools) and from within each year are treated separately and no attempt is made to investigate and discuss any combined effects at this stage. The investigation of the factors that may be linked with children's attitudes in primary and secondary schools will be presented and discussed in Chapter 5. The attitude changes taking place, for the longitudinal sample on transfer, are described and discussed in Chapter 7. These later chapters discuss important factors in some detail, and therefore in this chapter the discussion will be limited to those points that will not be raised again in later chapters.

The chapter is divided into three main parts dealing with the children (4.2), the teachers (4.3) and the schools (4.4). Each of these parts is subdivided into sections, which present:

- The data
- Relationships within the data
- Summary

The results presented have been processed into bar charts or simplified tables for convenience and readability, but all the original tables of the first processing of the data can be found in Appendix 4.The details of all statistical analyses and the treatment of missing data are given in Appendix 2.

4.2 The children's questionnaire

4.2.1 THE QUANTITATIVE QUESTIONNAIRE DATA

After validity checks and factor analysis (Lewis-Beck, 1994) on the questionnaire responses, seven factors were identified; two of these arose from Section One of the questionnaire, the attitudes to school section, and the remaining five from Section Two, the attitudes to science section. The children's responses to the questionnaire items are summarised in Tables 4-1 & 4-2 below; the items have been ordered so that items forming a single factor are grouped together.

In Section One, factor 1, is regarded as representing feelings about being at school, and is called the 'enjoyment of school' factor. Factor 2, contains only items dealing with work and behaviour at school, and is called the 'schoolwork' factor. These two factors were common to both the primary and secondary surveys and to the pilot surveys.

Table 4-1: The children's responses to Section 1 of the questionnaire.

			Sector	n	Agree %	Undecided %	Disagree %
Perceptions of schoolwork	Q.9	I get good marks for my work	Primary	2815	52.18	35.63	12.19
			Secondary	2630	60.07	30.84	9.09
	Q.10	I always work as hard as I can at school	Primary	3210	71.00	16.42	12.58
			Secondary	2818	71.54	17.46	11.00
	Q.11	I always behave badly at school	Primary	3156	4.19	9.19	86.63
			Secondary	2799	2.75	7.00	90.25
Enjoyment of school	Q.6	I enjoy everything about school	Primary	3159	40.04	34.06	25.89
			Secondary	2794	23.98	29.74	46.28
	Q.7	I am bored most of the time at school	Primary	3195	15.65	13.99	70.36
			Secondary	2820	19.18	18.26	62.55
	Q.8	There are lots of school subjects I don't like	Primary	3158	21.82	15.39	62.79
			Secondary	2816	31.22	14.35	54.44
	Q.12	School is not very enjoyable	Primary	3201	17.00	15.15	67.85
			Secondary	2805	23.07	21.39	55.55

In Section Two, factor one (f1) is the 'enjoyment of science' factor and reflects both 'enjoyment of science lessons' and 'enjoyment of practical work'. Factor two (f2) contains three items about difficulties in science, and so this factor will be called 'the difficulty of science'. The remaining factors were designated in a similar manner, to reflect the items included, thus:

Factor 3 (f3)	Attitude to computers in science
Factor 4 (f4)	The difficulty of written work in science
Factor 5 (f5)	Perceptions of progression and continuity in science

These seven factors (two school factors and five science factors will be referred to from here on as 'attitude sub-scales' and are used to calculate children's 'attitude' scores (see Appendix 5 for details of the factor analysis and the calculation of attitude scores).

(See Table 4-2 on page 193)

Table 4-2: The children's responses to Section 2 of the questionnaire

			n	Sector	Agree %	Undecided %	Disagree %
Enjoyment of science	Q. 13	I look forward to science lessons	3188	Primary	63.58	21.27	15.15
			2808	Secondary	53.42	26.92	19.65
	Q. 16	I don't like science lessons	3237	Primary	12.23	13.38	74.39
			2859	Secondary	13.6	15.60	70.79
	Q. 30	I enjoy going to science lessons	3133	Primary	68.37	18.70	12.93
			2828	Secondary	59.66	22.21	18.14
	Q. 21	I like doing experiments	3294	Primary	89.58	4.86	5.56
			2897	Secondary	93.44	2.87	3.69
	Q. 27	Doing experiments is a waste of time	3252	Primary	4.61	5.50	89.89
			2863	Secondary	2.93	4.26	92.80
The difficulty of science	Q. 18	There are too many facts to learn in science	3086	Primary	36.74	25.86	37.39
			2788	Secondary	38.27	23.67	38.06
	Q. 20	There are too many new words to learn in science	3057	Primary	45.05	23.68	31.27
			2830	Secondary	45.22	19.89	34.88
	Q. 31	There are too many new ideas to learn about in science	3025	Primary	34.15	26.71	39.14
			2763	Secondary	30.98	26.24	42.78
The difficulty of written work in science	Q. 25	I'm not always sure how to write about experiments I have done	3217	Primary	55.95	18.53	25.52
			2842	Secondary	51.62	16.01	32.37
	Q. 29	Science is difficult when it involves writing	3181	Primary	29.74	20.84	49.41
			2824	Secondary	24.61	20.68	54.71
	Q. 35	Writing about why I did an experiment is difficult	3090	Primary	40.25	23.98	35.76
			2770	Secondary	37.8	23.00	39.21
Attitude to using computers in science	Q. 14	Science is more interesting when we use computers	2920	Primary	68.66	15.55	15.78
			2222	Secondary	43.34	25.88	30.78
	Q. 19	Using a computer makes science so interesting I don't want to stop	2859	Primary	53.86	20.64	25.50
			2175	Secondary	27.63	29.70	42.67
	Q. 22	When I use a computer in science I understand things better	2737	Primary	59.63	24.41	15.97
			2061	Secondary	34.89	41.87	23.24
Perceptions of progression in science	Q. 23	I already know the science my teacher teaches us	2984	Primary	14.61	27.35	58.05
			2756	Secondary	14.04	28.74	57.22
	Q. 26	The ideas we learn about in science are too easy	3155	Primary	8.5	19.62	71.89
			2813	Secondary	6.4	19.27	74.34
	Q. 34	I already know most of the science we have done this year	2970	Primary	17.57	21.14	61.28
			2785	Secondary	21.22	20.68	58.10

The mean values on the standardised sub-scales for primary and secondary school children are compared in Table 4-3. In each case the range is 1-5, where 1 indicates the least agreement with the concept and 5 indicates the most agreement, and 3 is the mid-point.

Table 4-3: Standardised attitude scores for the children's questionnaire sections 1 & 2

	Significance of difference between years 6 & 7	Year 6			Year 7		
		N	Mean	Std. Deviation	N	Mean	Std. Deviation
Enjoyment of school	**	1851	3.57	0.78	2572	3.27	0.84
Enjoyment of schoolwork	**	1710	3.88	0.64	2484	3.96	0.60
Enjoyment of science	*	1883	4.07	0.74	2672	4.00	0.76
The difficulty of science	ns	1807	3.03	0.90	2621	3.00	0.94
The difficulty of science writing	**	1912	3.07	0.88	2665	2.94	0.89
Attitude to computers in science	**	1650	3.68	0.94	1961	3.08	0.93
View of progression	#	1764	3.68	0.75	2613	3.63	0.75

** Correlation is significant at the 0.001 level (2-tailed).
* Correlation is significant at the 0.01 level (2-tailed).
# Correlation is significant at the 0.05 level (2-tailed).

Paired t-tests were used to look for any significant[1] differences between the attitude sub-scale scores in primary and secondary school. The results indicate statistically significant differences between attitudes in years 6 and 7 for all sub-scales except the difficulty of science sub-scale. But, the significance levels for the enjoyment of science ($p<0.01$) and the perceptions of continuity and progression ($p<0.05$) are low, and, given the large number of pupils involved, may not have any educational importance.

4.2.1.1 Overview

Enjoyment of school declines significantly on moving from year 6 to year 7 for this sample of children, but attitudes to schoolwork appear to become more positive after transfer.

A comparison of the mean values for enjoyment of science in years six and seven shows that children at the end of primary school have a very positive

[1] The use of the words 'significant', 'significantly' and 'significance' refer to *statistical significance* throughout Chapters 4 to 8.

attitude to science, which then declines slightly *after* transfer to secondary school. However, this comparison does not take account of the changes in children's enjoyment of school, and it will be recalled that attitudes to school science are likely to be related to more general attitudes to school. The effects of enjoyment of school on enjoyment of science will be investigated later (pages 214-216).

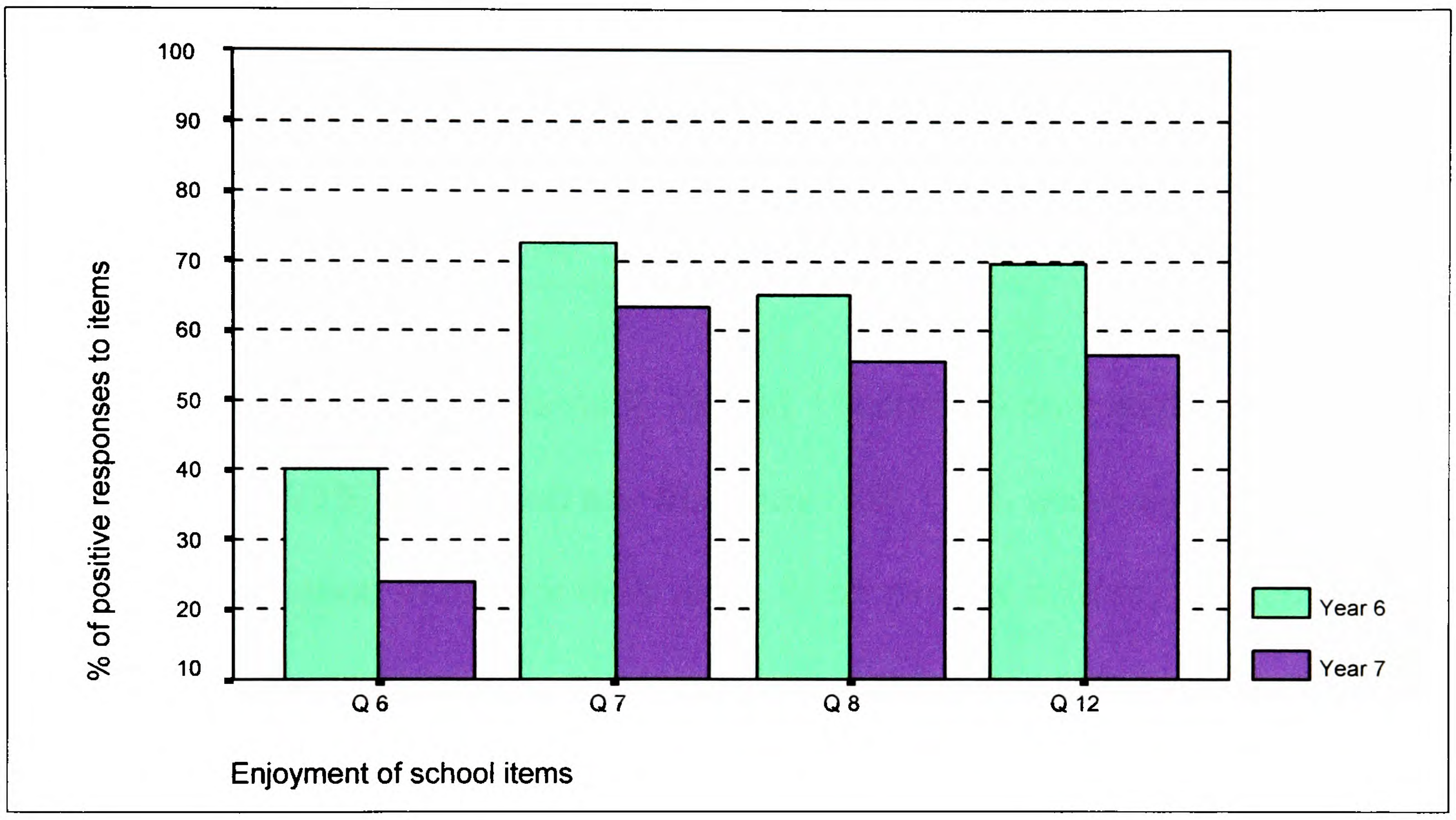
When the other science attitude sub-scales for years 6 and 7 are compared, the mean values indicate that perceptions of the difficulty of science *does not change* significantly on transfer, and perceptions of continuity and progression are only slightly different ($p<0.05$) in the two sectors. Furthermore, average scores on the difficulty of written work in science, *decrease* significantly on transfer, suggesting that these children may find written work in science *less difficult after transfer*. The overall impression given by these data is that, on transfer, although children may become *less* positive about science lessons generally, they may become *more* positive about particular aspects of science lessons.

4.2.1.2 Section One of the Children's Questionnaire: Attitudes to School

The attitude sub-scales and t-tests suggest a significant decline in enjoyment of school on transfer for these two groups of children, as indicated in Figure 4-1, below. The responses to items reflecting enjoyment of school (6, 7, 8 and 12) suggest that in the final year of primary school the majority of these children are very positive about school, but there is a group who seem to have less positive views. For example, 16% say they are bored most of the time at school, and 17% say that school is not very enjoyable. After transfer the proportion of positive responses declines quite sharply, with a sizeable minority expressing negative views. The proportion of children choosing to respond positively declines on every item in this group.

The proportion agreeing that school is not very enjoyable increases from 17% to 23% on transfer, and the proportion agreeing that they enjoy everything about school falls from 40% to 24%.

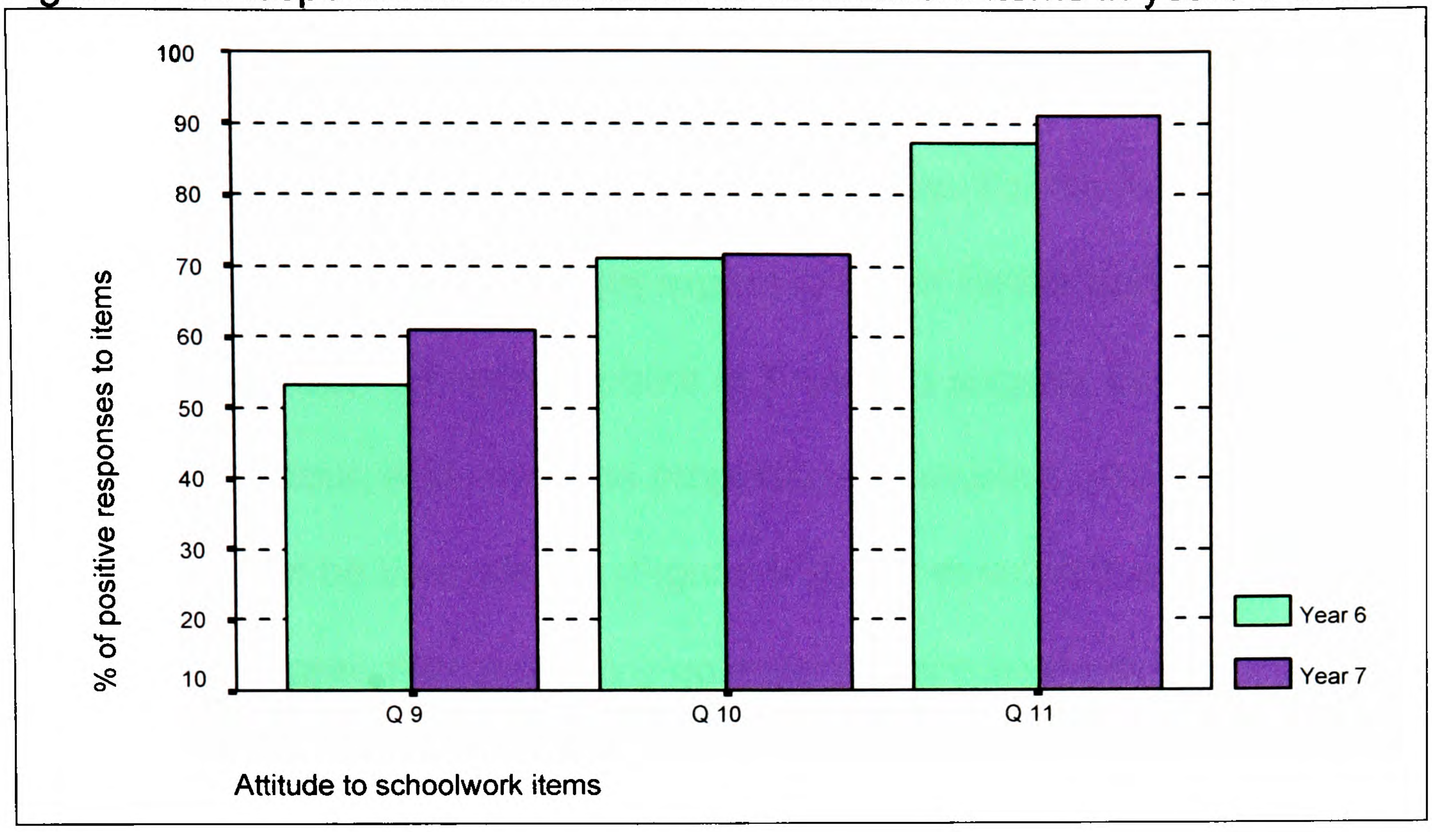
Figure 4-1: Responses to the enjoyment of school items in years 6 and 7



These results are in agreement with earlier research into changes in attitudes to school on transfer (Galton & Wilcocks, 1983; Mortimore et al, 1988; Barber,1994; Keys, Harris & Fernandes,1995; Blatchford,1996; Galton, Gray, & Rudduck, 1999) indicating a decline in positive feelings about school. As the literature has indicated, such a decline may be associated with increasing maturity; it may be a product of the transfer process or perhaps a combination of both effects.

In contrast, attitudes to schoolwork appear to improve after transfer (Figure 4-2), and this dichotomy suggests that although attitudes to school become less positive, the work at secondary school may be easier.

Figure 4-2: Response to the attitudes to schoolwork items in years 6 and 7



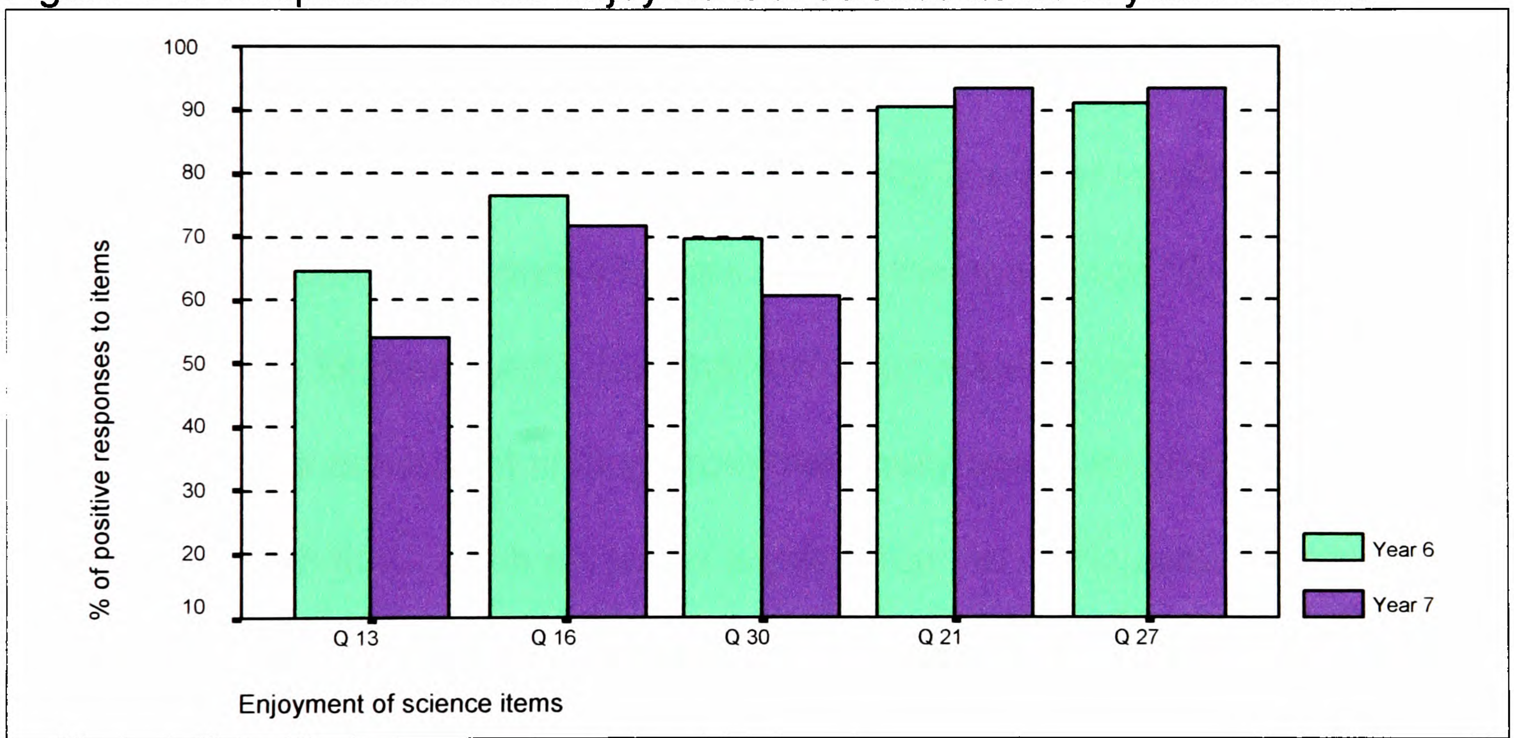
Perceptions of schoolwork (items 9, 10 and 11) change only slightly on transfer. In primary school 71% of children say that they work hard, and only 12% say that they do not get good marks for their work. At secondary school the proportion that say they work as hard as they can is very much the same (72%), although more children think that they get good marks (60% at secondary school, in contrast to 52% at primary school). These results suggest that some children may find secondary school work easier than primary school work; echoing the 'easy riders' observed by Galton et al (1983), however, the changes are very small. The proportion of children who are prepared to say that they behave badly amounts to 4% of the sample in year 6 and 2% in year 7, but another group (9% in year 6 and 7% in year 7) is not willing to disagree with this statement. There is also a group who disagree that they always work as hard as they can; 13% in year 6 and 11% in year 7. These results suggest that there may be a small group of children with negative attitudes to schoolwork before and after transfer to secondary school.

4.2.1.3 SECTION TWO OF THE CHILDREN'S QUESTIONNAIRE: ATTITUDES TO SCIENCE

4.2.1.3.1 Enjoyment of science

If attitudes to school and to school science are significantly related, as the literature indicates, then we might expect to find a similar decline in enjoyment of science. The mean sub-scale scores in Table 4-3 suggest that such a decline does indeed occur, and when the proportions of positive responses are examined this decline can be seen clearly (Figure 4-3). For example the proportion of children who agree that they enjoy going to science lessons decreases on transfer from 68% to 60%.

Figure 4-3: Responses to the enjoyment of science items in years 6 and 7



There appears to be a dichotomy within the 'enjoyment of science' items (13, 16, 30, 21 and 27). Practical work (items 21 and 27) is evidently much enjoyed in both years 6 and 7, and there is a rise in the proportion of children responding positively to these items after transfer. On the other hand there is a decline in the proportion of positive responses to feelings about science lessons (items 13, 16 and 30). Factor analysis indicates that these children perceived practical work as an integral part of science lessons (see Appendix 5) and, as the responses indicate, it is enjoyed by an increasing number of children after transfer. However, the decline in the proportion of positive responses to items 13, 16 and 30 implies that there must be other aspects of science lessons that are less enjoyable at secondary school.

Enjoyment of science lessons appears to decline on transfer. In this respect, the results from this sample of children, in Essex, in 1996, are very similar to those from other groups of children at other times. In 1981, in Scotland, children's enjoyment of science was shown to fall by approximately 10% on transfer (Hadden, 1981). Enjoyment of science was observed to fall slightly, for a random sample of English children, in 1987, and again, more recently in 1997 (Keys, 1987 & 1997), in cross-sectional studies of children aged 9-10 years and 13-14 years. In America (for example, Hofstein & Welch, 1984;Simpson & Oliver, 1985; Yager & Penick, 1986; Piburn & Baker, 1993) similar results have been obtained using cross-sectional samples across the age-range 10-13 years. Evidence of this kind suggests that children's attitudes to science fall on transfer, and that this is a consistent finding cross-nationally and is independent of changes in education with time. Such evidence implies that the curriculum changes of the last 10 years (in particular, the introduction of National Curriculum science in primary schools) may have had no effect on children's attitudes to science. However, there are other changes on transfer, which should not be ignored, and which suggest that a more rigorous analysis of the present data may be necessary if a valid picture is to emerge. The positive changes in some aspects of attitudes to science lessons suggest a more complex picture than indicated above.

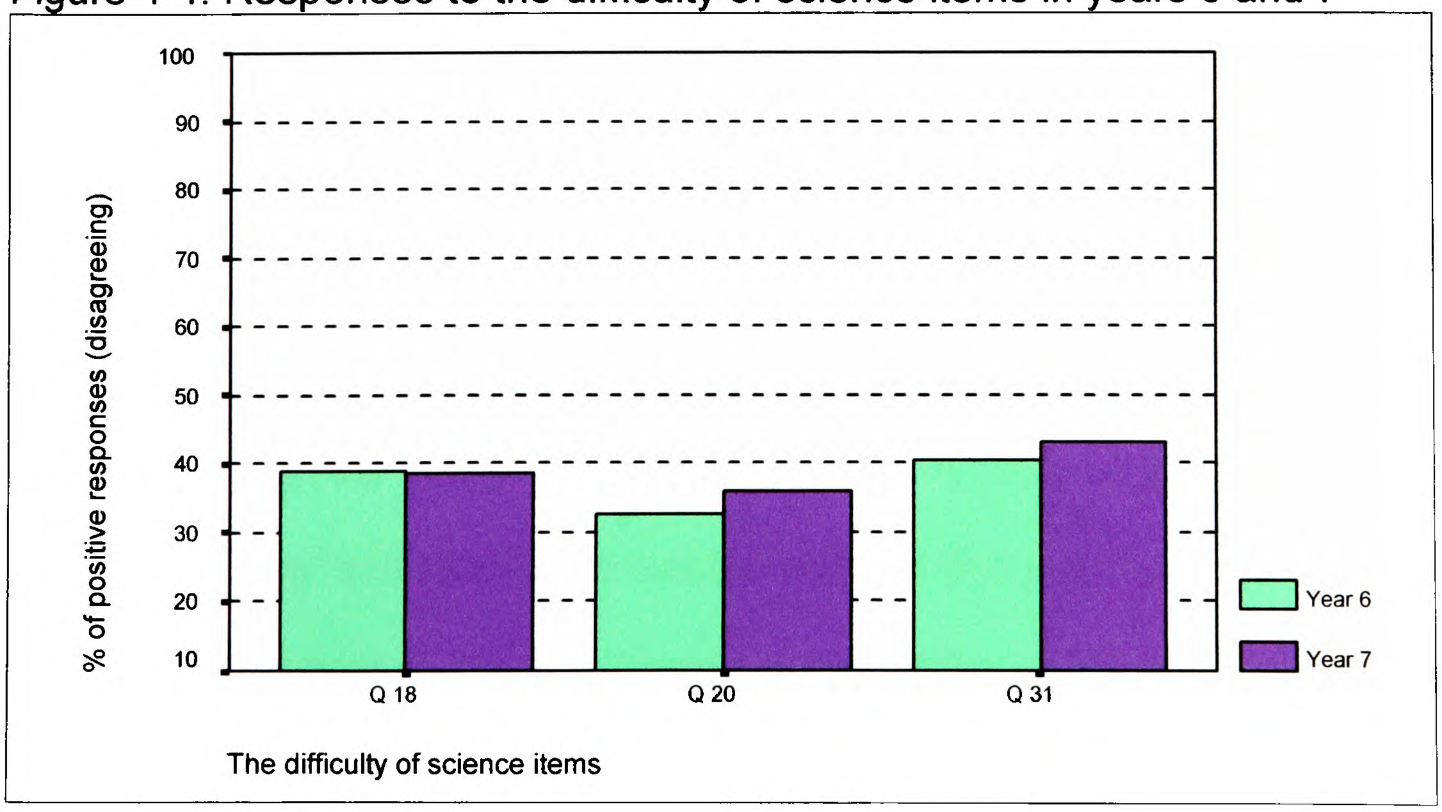
Furthermore, the relationship between attitudes to school and attitudes to science has not yet been taken into account; clearly there is a considerable fall in positive attitudes to school.

The positive or negative wording of questionnaire items appears to have influenced the children's responses. More children were prepared to agree with statements when they were couched in less effusive language! For example, in response to the most positive statement: 'I look forward to science lessons' only 64% agreed (Table 4-2). But, 68% agreed with the slightly less positive: 'I enjoy going to science lessons' and when asked to respond to a negative statement about science: 'I don't like science lessons' 74% disagreed (i.e. claimed to like science lessons). Thus, the use of an average score across all the items within a factor probably gives a better overall representation of the attitude than using each item separately. Such a summated score takes into account the shades of meaning within different items.

4.2.1.3.2 <u>The difficulty of science</u>

Although the difficulty of science scores do not appear to be significantly different for years 6 and 7 (Table 4-3), the responses to the 'difficulty of science' items (18, 20 and 31) show that opinions were divided about the difficulties met in science lessons (Figure 4-4).

Figure 4-4: Responses to the difficulty of science items in years 6 and 7



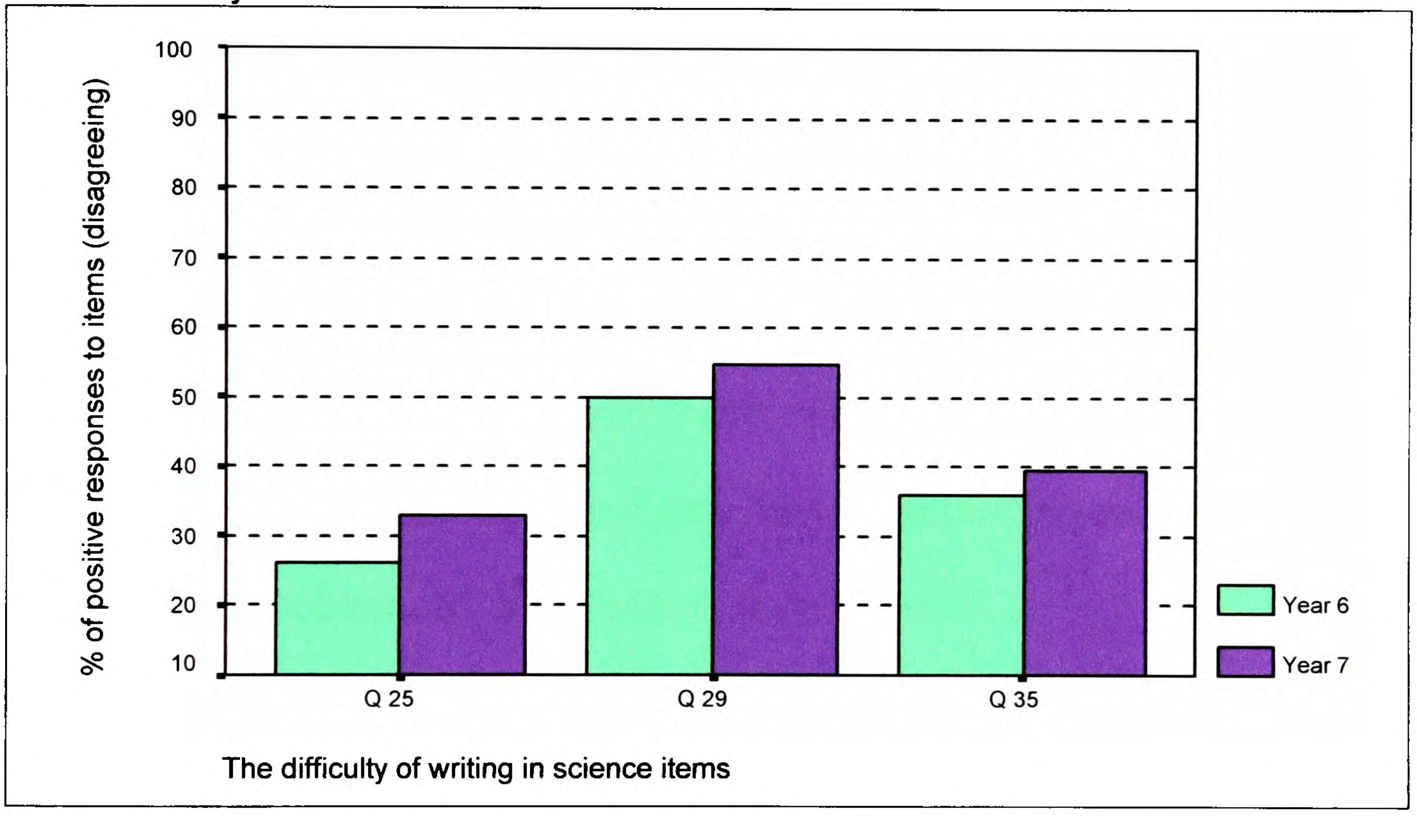
For example, 37% of all these children at primary school agreed that there are too many facts to learn in science, but another 37% disagreed. Similarly although 34% agreed that there are too many new ideas to learn in science, a further 39% disagreed. There was rather more agreement about the vocabulary of science, with 45% agreeing that there are too many new words to learn in science, and only 31% disagreeing. These figures suggest that at primary school, although some children might have problems with factual knowledge and concepts others do not experience this difficulty, but the vocabulary of science may be a more general problem. The changes on transfer are interesting. For items 18 and 20 there was a very small increase in the proportion who felt that there were too many new facts or words, suggesting that these children did not feel there was an increase in the amount of factual information and vocabulary they were receiving. However, for item 31 there was a fall in the proportion of children who felt that there were too many new ideas to learn, suggesting that the introduction of new concepts were not seen as particularly problematic at secondary school.

It has been suggested that children find science increasingly difficult and that this might explain the apparent decrease in enjoyment of science with age (Piburn and Baker; 1993; Havard, 1996; Sears, 1997). But on the evidence of the mean scores (Table 4-3), this does not seem to explain the decline in enjoyment of science on transfer; there is no overall increase in the scores on either the 'difficulty of science' scale or on the 'difficulty of written work' scale. Thus, for this sample although the enjoyment of science score declines on transfer, scores on the two 'difficulty' scales indicate that the children find science easier in year 7 than they did in year 6. So, at this stage of schooling, the decline in positive attitudes to science appears to lie elsewhere. There is a tendency for children to feel that, after transfer, there are less new words and facts to assimilate.

4.2.1.3.3 <u>The difficulty of written work</u>

The difference in the scores on the 'attitudes to written work in science' scale is statistically significant and there are more children who have become more positive about written work than have become negative, across all three items about science written work (Figure 4-5).

Figure 4-5: Responses to the difficulty of written work in science items in years 6 and 7



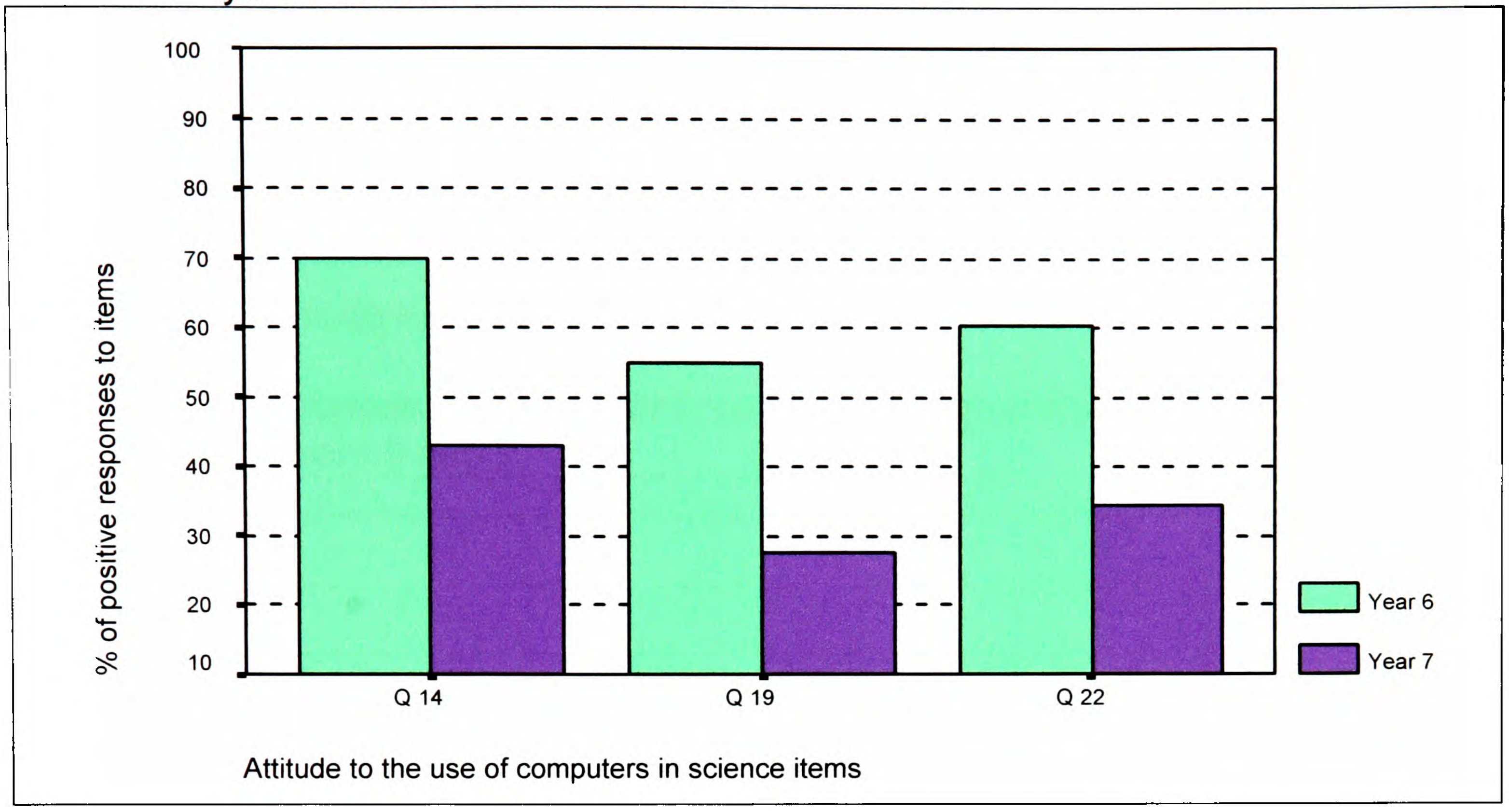
There were interesting differences in the responses to the individual items in 'the difficulty of written work in science' sub-scale (items 25, 29 and 35). It was expected that many children would have rather negative attitudes to written work since the pilot studies had indicated that written work in science seemed to be a problem area for children. Indeed, the responses of the primary school children suggested that written work was an issue, with 56% agreeing that they were not always sure how to write about experiments they had done (item 25).

A smaller, but still substantial group (40%) of children agreed that 'writing about why I did an experiment is difficult' (item 35). However, the item dealing with writing as an activity in science lessons: 'Science is difficult when it involves writing' (item 29) elicited a different response from the other two items, only 30% of the children agreed with this statement, and almost half of the children (49%) disagreed. The first two items dealt with the underlying understanding needed in order to write; the *why* and the *how* rather than the more general difficulty of producing written work. In interviews the primary school teachers, discounted children's apparent difficulties with written work in science, suggesting that children did not enjoy written work generally, and that this accounted for such responses. However, the responses presented here suggest that it is not written work in general that is the problem, but the *understanding* required in order to do the writing. The changes in the children's responses on transfer indicate that both the mechanics of written work and also the understanding required for writing become less problematic at secondary level.

4.2.1.3.4 <u>The use of computers</u>

There is a significant decline in positive 'attitudes to the use of computers in science'. Large negative changes are observed on transfer (Figure 4-6). These large-scale changes in attitudes to using computers may well be associated with the extremely low utilisation of computers in the first year of secondary school. Over 50% of children reported a fall in the frequency of use of computers and over 75% said they never used computers in secondary science lessons. Very few schools made a feature of ICT in connection with science work and lack of familiarity most probably caused the observed changes.

Figure 4-6: Responses to the attitudes to the use of computers in science items in years 6 and 7

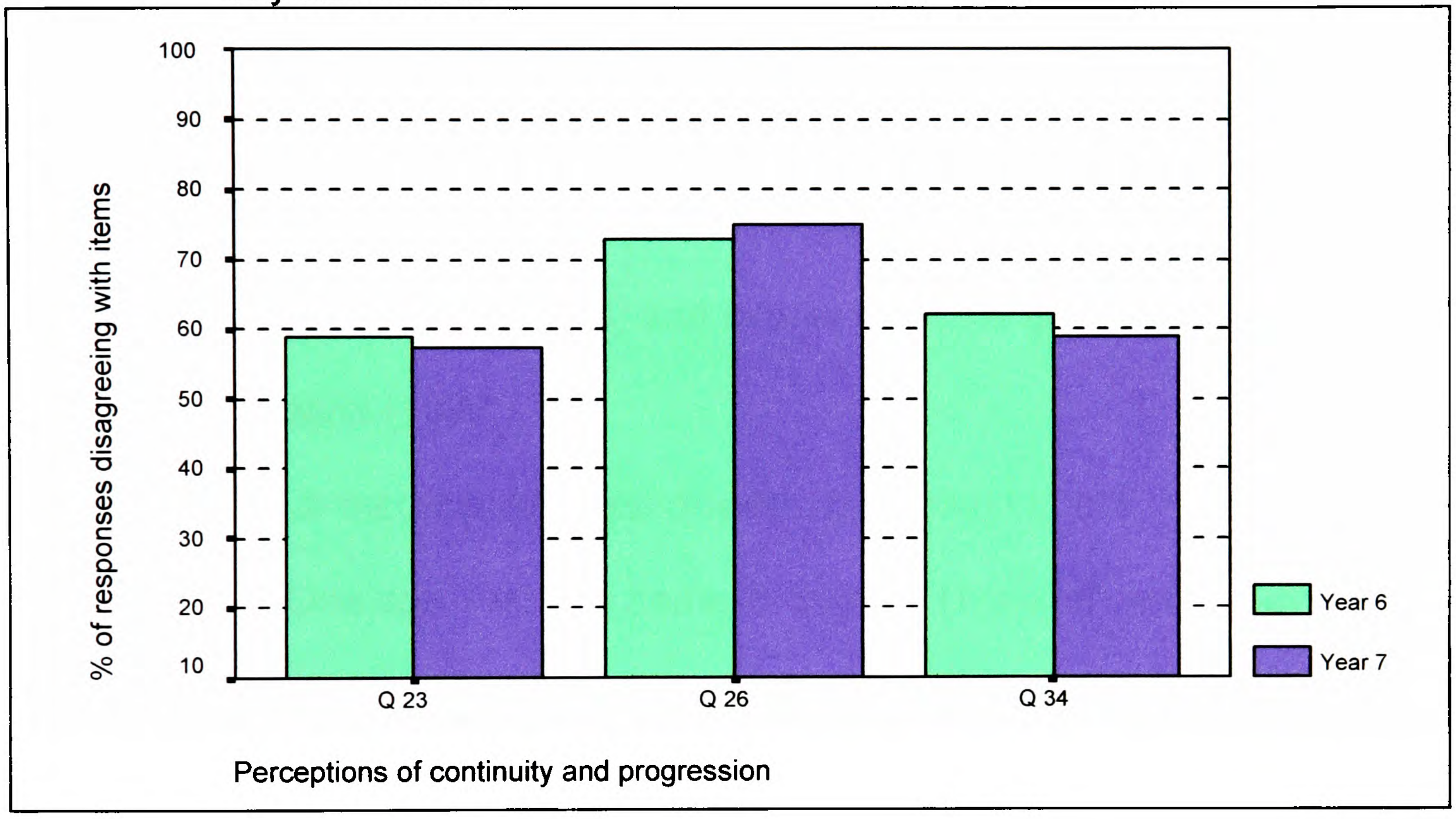


At primary level attitudes to using computers in science lessons were very positive (items 14, 19 and 22). Only a small minority (16%) disagreed with the general statement that 'science is more interesting when we use computers' (item 14). But, it must be borne in mind that many of these children may not have had much experience of using computers in science lessons. At secondary level there was a striking decline in the proportion of positive responses to all three items, for example, agreement that 'using a computer make science so interesting that I don't want to stop' (item 19) fell from 54% to 28%. These changes may represent a change in attitude to the use of computers in science, but are more likely to reflect a decline in use of computers in science at secondary school (see Table 4-4, page 200).

4.2.1.3.5 <u>Perceptions of continuity and progression</u>

The small change in perceptions of continuity and progression suggests little change in these views on transfer, and the t-test indicates that the difference is only just statistically significant ($p<0.05$). Furthermore, this small change may not be meaningful because of the low reliability of this sub-scale. The responses to items concerning continuity and progression (items 23, 26 and 34) suggest that the majority of children did not have a strong feeling that work was being repeated in year 6, even though there was a substantial amount of revision for the end of key stage tests in their final year (Figure 4-7).

Figure 4-7: Responses to the perceptions of continuity and progression items in years 6 and 7



The large number of children who responded by ticking the 'undecided' box could be interpreted as showing that children thought work *might be* being repeated. However, an alternative interpretation is that the children did not have a clear enough understanding of the work to be able to make a judgement. More than half of the children felt that work in year 6 was new, for example, 58% disagreed that they already knew the science they were being taught (item 23).

Furthermore, the majority regarded the work in science as challenging since 72% disagreed that the ideas they learned about in science were too easy (item 26). These figures did not change appreciably after transfer to secondary school; only 14% agreed that they already knew the science they were being taught (item 23). However, the proportion that agreed that 'I already know most of the science we have done this year' (item 34) was considerably higher, at 21%, than the primary school figure of 18%. But the 'undecided' response was lower and the 'disagree' response remained similar; possibly there was some doubt in the children's minds about the exact meaning of this statement. As in primary school, a very large proportion of the children *disagreed* with the statement 'the ideas we learn about in science are too easy' (item 26). Only 6% of these children agreed with this statement; suggesting that even if work is not exactly new it is certainly more demanding; this idea was also expressed by the children in the study by Hawkey and Clay (1998) and overall the findings here are very similar to those of Sutherland (1996).

4.2.1.4 SECTION THREE OF THE CHILDREN'S QUESTIONNAIRE: CLASSROOM ACTIVITIES

As in Sections One and Two, the items in Section Three (shown in Table 4-4 below) were subjected to factor analysis. Factor 1 includes items where discussion, co-operation and collaboration might be expected to occur and is described as 'Collaborative activity', factor 2 includes items, which may involve standard texts or software, often having relevance to particular sections of the curriculum, and so is described as 'Standardised activity'. The items in factor 3 concern activities where the students, rather than the teachers are in control of activities. In contrast, the items in factor 4 are activities controlled by the teacher. Hence, factor 3 is described as Student directed learning, and factor 4 is described as Teacher directed learning. The use of library books did not load particularly strongly on any one factor; it appeared to be associated in the minds of the primary school children with both collaborative activity and with standardised activity, and is omitted from any of the factors (see Appendix 5).

Table 4-4: The children's responses to Section 3 of the questionnaire.

Factor		Questionnaire items	n	Sector	Never %	Less than half our lessons %	Half our lessons %	More than half our lessons %	Every lesson %
Teacher directed	Q38	We copy the teacher's notes from the board or worksheet	3019	Primary	13.15	27.76	28.16	17.79	13.15
			2801	Secondary	1.96	20.21	23.88	28.60	25.35
	Q46	We watch the teacher do experiments	2941	Primary	29.00	32.95	16.70	10.34	11.02
			2775	Secondary	6.16	30.74	26.02	22.81	14.27
Student directed activity	Q39	We make up our own experiments and the teacher helps us to make a plan to do them	2695	Primary	37.18	26.64	16.22	12.54	7.42
			2573	Secondary	60.79	20.75	9.52	6.96	1.98
	Q40	We choose the topics we want to study	2922	Primary	81.93	10.54	4.00	1.61	1.92
			2696	Secondary	93.21	4.71	1.04	0.56	0.48
	Q45	We work on our own to do experiments	2912	Primary	44.54	29.46	14.80	7.21	3.98
			2723	Secondary	57.84	28.87	7.20	4.44	1.65
Standardised activity	Q36	We use text books	2709	Primary	50.02	17.31	15.65	10.30	6.72
			2730	Secondary	4.29	29.27	21.50	27.22	17.73
	Q43	We have tests on what we have learned	2676	Primary	22.57	35.72	18.46	13.04	10.20
			2622	Secondary	1.83	46.15	26.35	18.12	7.55
	Q47	We use computers	2901	Primary	33.13	33.13	17.17	11.17	5.41
			2660	Secondary	75.00	20.15	3.12	1.50	0.23
Collaborative activity	Q41	We talk in a group about our ideas	3059	Primary	6.54	24.98	26.15	18.73	23.60
			2687	Secondary	13.21	29.88	24.67	19.20	13.03
	Q42	We talk to the teacher about our ideas	3023	Primary	5.76	22.36	21.10	21.17	29.61
			2657	Secondary	9.79	26.53	22.69	21.64	19.35
	Q44	We work in small groups to do experiments	3007	Primary	5.09	16.99	25.27	24.81	27.84
			2819	Secondary	1.31	7.38	18.20	39.66	33.45
	Q37	We use library books	2764	Primary	17.80	40.99	23.55	12.45	5.21
			2428	Secondary	71.75	24.34	2.47	1.15	0.29

At secondary level the factors that emerged were more complex, than those produced from the year 6 data. Factor 1 for the secondary school data indicated that discussion was linked with free choice. There seem to be two possible explanations for this observation. The first possibility is that these children may have regarded discussion as an expression of autonomy; but it is clear from their responses to these items that free choice was a rare experience at secondary

School. This gives rise to an alternative explanation: that this factor simply represents activities occurring infrequently.

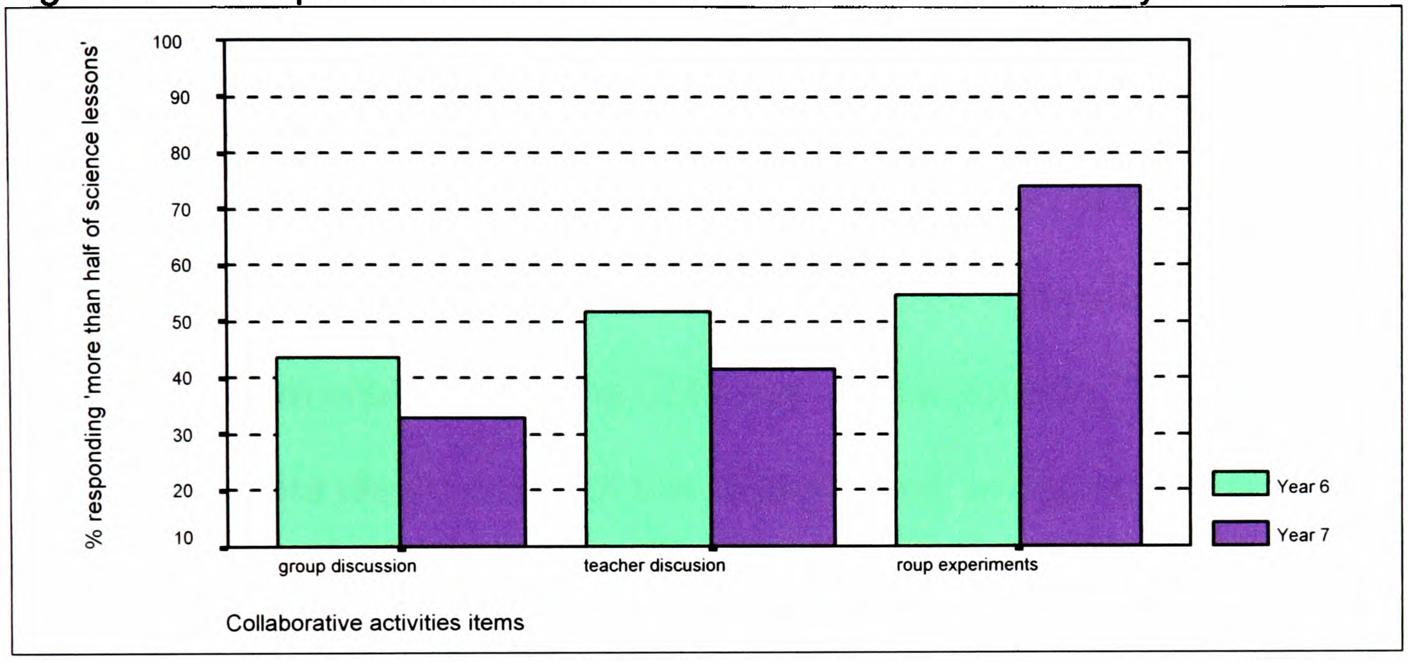
Factor 2 (from the analysis of secondary school data) places 'working in small groups to do experiments' with teacher directed activities, such as teacher demonstrations. This suggests that at secondary school the children regard group experimental work as a teacher directed activity rather than as a collaborative activity.

Working alone on experimental tasks at secondary school is part of the same factor as is having tests, suggesting that this activity may be regarded as part of the testing process; investigations, used for assessment purposes are often worked on individually at secondary school, rather than as part of a group activity. These differences seem to reflect some of the changes in teaching approaches on transfer from primary to secondary school, and these changes may affect children's views on science lessons.

It was felt that the factors that emerged from the year 6 analysis could be particularly useful in tracking such change in approach. Only a small number of distinct factors had been found for the year 6 pupils, and these factors could be interpreted in terms of quite general classroom activities. Furthermore, it was argued that if the different factors emerging in year 7, were a result of the changes in teaching approaches, then using the year 6 factors throughout would provide a measure of the changes in the teaching approaches.

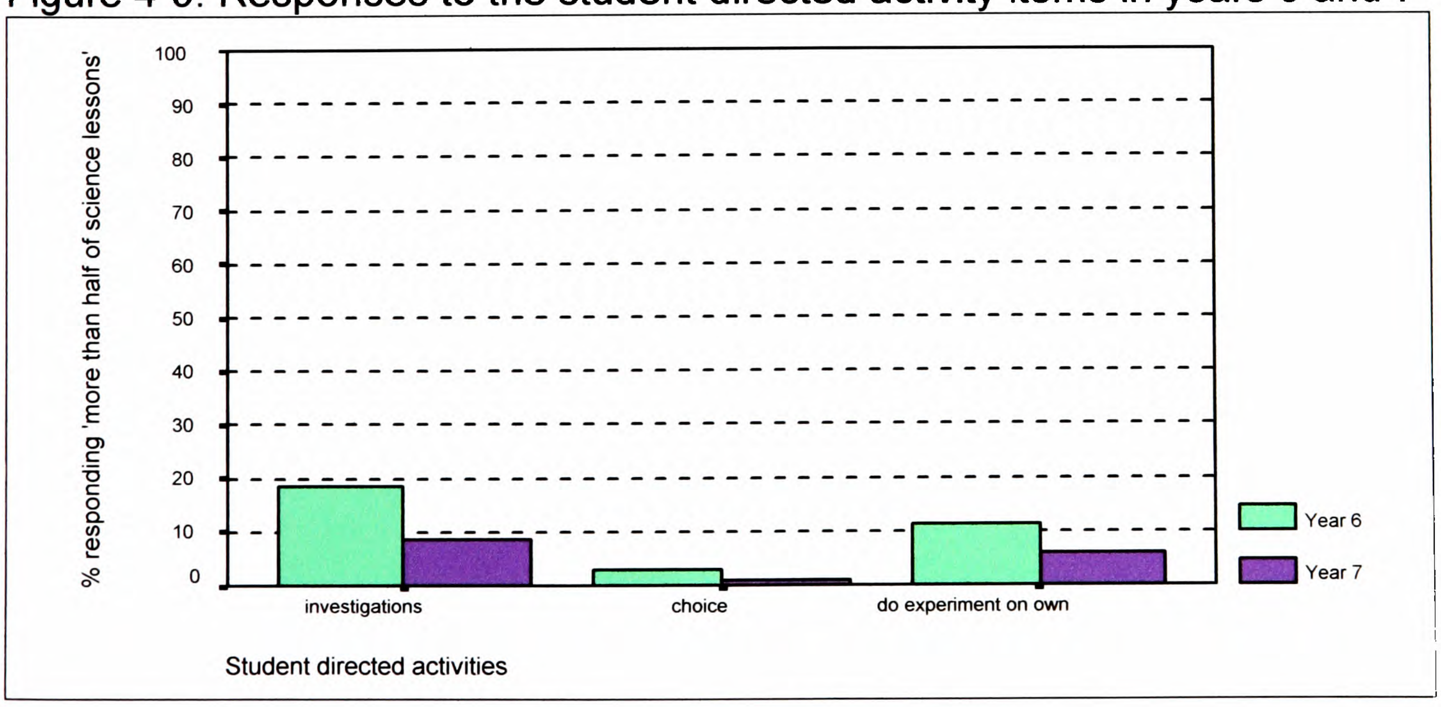
To some extent the changes in activities are much as would be expected in terms of the generally recognised differences between primary and secondary in science teaching approaches[1]. Availability of laboratories and specialist teachers at secondary school most probably lead to some of the changes in collaborative activity (Figure 4-8); at secondary school there is certainly more emphasis on practical activities - of certain types.

Figure 4-8: Responses to the collaborative activities items in years 6 and 7



There appears to be more small-group practical work at secondary school (item 44), but less independent practical work (item 45), and greater use of teacher demonstration (item 46). However, the student directed activity items (Figure 4-9) suggest that there is also less freedom of choice at secondary school.

Figure 4-9: Responses to the student directed activity items in years 6 and 7



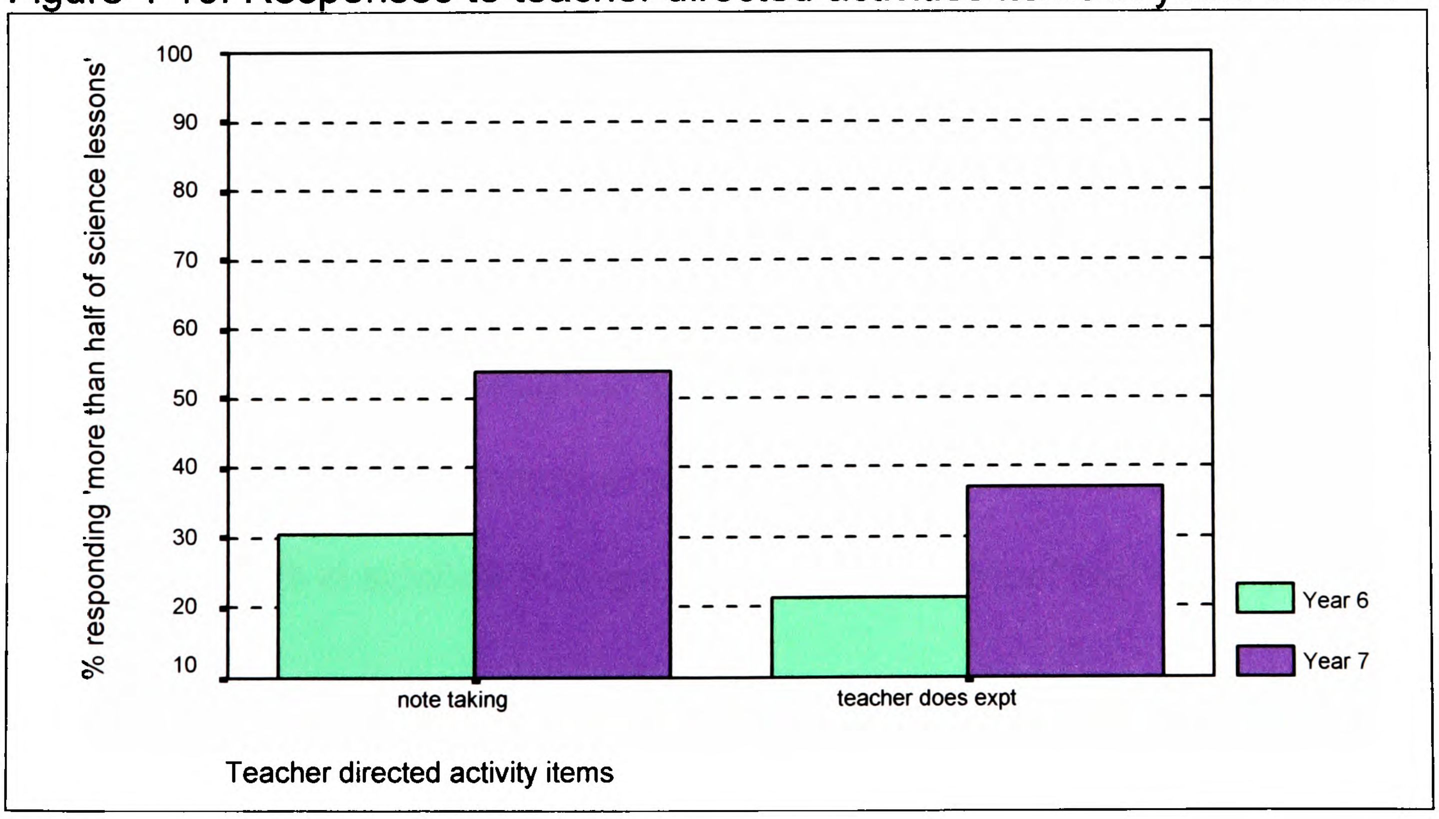
[1] These differences were discussed in some detail in Chapter 1.

This is probably because topics are generally agreed as part of an overall programme of study by secondary science departments and there is very little flexibility; whereas, primary teachers, although constrained by the National Curriculum, may have greater flexibility in planning because of the different nature of classroom organisation.

Both the teacher-directed activities and the student-directed activities probably relate to the level of control used by the teacher and the level of autonomy for the child. Copying the teacher's notes and watching the teacher do experiments are areas where the child has least autonomy. These are also activities that are less in line with the child-centred, experiential approach, which is still adopted widely in primary schools. The responses in Table 4-4 (page 200) suggests that only a minority of time is spent on such activities in primary school, but that this increases considerably on transfer to secondary school.

At primary school the extent to which children felt that they had some control of their science activities was notable (Figure 4-9).

Figure 4-10: Responses to teacher directed activities items in years 6 and 7

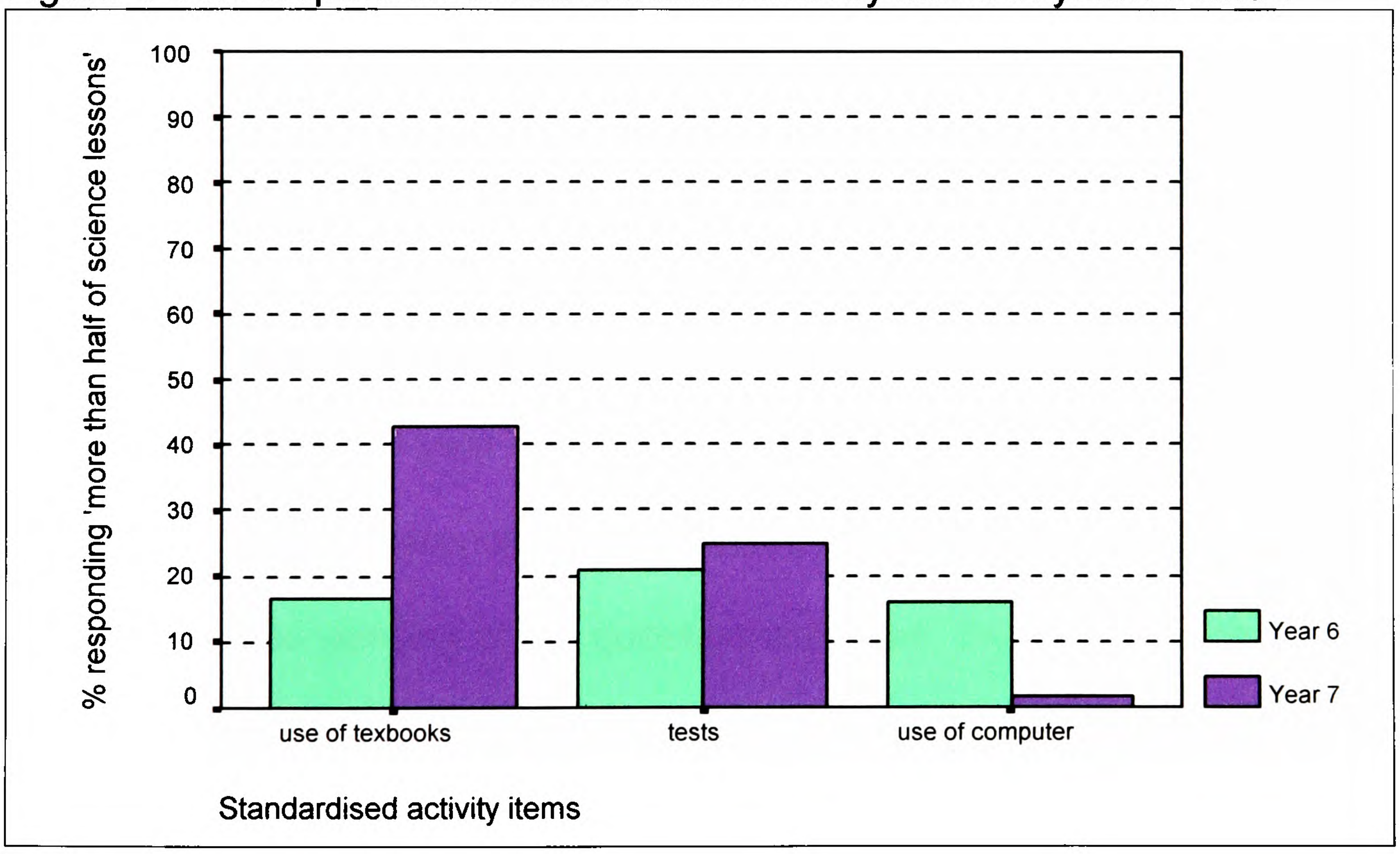


A quarter of the children (26%) thought that they did practical work on their own (item 45) in at least half of their science lessons, and 36% thought that they were allowed to make up their own experiments, with the teacher's help (item 39).

But it would appear that, for these children, such autonomy was rarely possible at secondary school; 58% of children said that they never worked on their own to do experiments, and 61% said that they never had the opportunity to make up their own experiments[1].

Every primary school visited for the survey had at least one computer per classroom, so the discovery that so few children had used computers for science-related work was unexpected (Figure 4-11).

Figure 4-11: Responses to standardised activity items in years 6 and 7



Almost one third of the children at primary school (33%) claimed never to have used computers in science lessons; at secondary school this figure rose to 75%.

[1] There were also interesting differences in the responses of boys and girls to these items; boys appeared to think that they did significantly more working on their own to do experiments and talking to the teacher about their ideas than did girls, at primary school. However, at secondary school these differences were not found. Could this have been an artefact or is there a real differences in teacher pupil interactions at primary school and do boys actually get more opportunities than girls to do practical work in primary school?

At primary school only 17 % said that they used computers often, and this figure fell dramatically on transfer to just 2%. It appears that these children felt that they rarely used computers in secondary school.

The frequency of use of textbooks and library books in the course of science lessons in primary schools was different from that in secondary schools. Books were sometimes used in primary science lessons, but not frequently, 50% of the primary school children in this sample said that they never used textbooks, and 18% said that they never used library books. The use of textbooks was much more common at secondary school, with only 4% of children saying that they never used textbooks. Whereas the use of library books was very uncommon, 72% of children said that they never used library books in science lessons.

There is some evidence to suggest that the use of testing in science in the last year of primary school may have increased since the introduction of the National Curriculum. In the current survey, only 23% of children said that they never had tests on what they had learned in science, but in 1984, using a similar statement, 36% of 10-year olds responded that this never happened (Keys, 1987)[1]. The large difference between these figures could be put down to a slight difference in the wording of the questionnaire item, the survey methods and the geographical regions surveyed. The 1987 survey was a random national survey whereas the present survey was a random Essex survey. Perhaps the Essex Local Education Authority is unlike others in England, but the educational statistics presented in Chapter 3 (page 173) would suggest that Essex was in fact very representative of the 'average' LEA. It could be argued therefore that the

[1] Keys used the statement: 'We have tests on what we have learned in science' (with the responses: 'often', 'sometimes' and 'never') with a large random sample of 10 year-old children from English schools.

large difference between these figures reflects a change in the use of tests at primary school. This is further supported, in the present study, by similarity in the figures, before and after transfer, for children who said that they *often* had tests - 23% at primary school and 26% at secondary school. If tests were *less* common at primary school than at secondary school then children should perceive a substantial increase in the frequency of tests on transfer.

The collaborative learning sub-scale combines elements of co-operative and active learning, both of which have been indicated as important methods of improving motivation and achievement in the research literature (for example, Galton, 1992; Wellington, 1994; Kyriacou, 1997; Matthews, 2001). In primary school group discussions, teacher discussions and group work were the norm, only a very small proportion of children said that they never worked in a group (5%) or discussed in a group (7%) or with the teacher (6%), although about a quarter of the children said such discussions only happened infrequently.

At secondary school most of the children in this sample were frequently engaged in small group practical work, and only 1% said this never happened. However, the proportion of children who felt that they never discussed work with peers or with the teacher rose; 13% of children said that they never talked in a group about their ideas, and 10% said they never talked to the teacher about their ideas. So, it seems that most children take an active part in small group practical work (almost inevitably involving some informal conversation) but do not feel that they are formally invited to discuss their ideas.

The responses in this section indicate that, on transfer, the majority of these children see a fall in the amount of discussion and choice, and an increase in the amount of directed work. Since the research literature indicates that control and autonomy are important factors affecting attitudes to science (Simpson & Oliver, 1990; Tobin, Kahle & Fraser, 1990; Myers & Fouts,1992; Piburn & Baker,1993; Wong, Young & Fraser, 1997; Hanrahan, 1998), it is possible that changes in the amount of discussion and choice might have important effects on attitudes to science.

4.2.2 SUB-SCALES CORRELATIONS FROM THE CHILDREN'S QUESTIONNAIRE

Attitude theory suggests that the various aspects of attitude to science (measured by the sub-scales described in the previous section) might be closely related to each other, and might represent different elements in an attitude to science structure. Furthermore, the literature suggests that attitudes to school might affect attitudes to individual subjects. Consequently, relationships between the attitude sub-scales from the children's questionnaire were investigated. This was done by calculating the Pearson's correlation coefficients between each of the attitude sub-scale scores measured by this study (Table 4-5). This procedure provides an estimate of the strengths of the various associations; larger correlation coefficients indicate stronger associations. A positive sign indicates a positive relationship and a negative sign indicates a negative relationship.

Table 4-5: Correlations between attitude scores on children's questionnaire

Pearson's correlation coefficients	Sector	Enjoyment of science	Difficulty of science	Difficulty of science writing	Attitude to computers	View of progression	Enjoyment of school	Enjoyment of schoolwork
Enjoyment of science	Primary		-.343**	-.219**	.018	-.030	.318**	.166**
	Secondary		-.397**	-.254**	-.051*	-.005	.455**	.294**
difficulty of science	Primary	-.343**		.403**	.136**	-.015	-.319**	-.159**
	Secondary	-.397**		.476**	.228**	-.059**	-.423**	-.204**
Difficulty of science writing	Primary	-.219**	.403**		.126**	.034	-.303**	-.215**
	Secondary	-.254**	.476**		.196**	.011	-.368**	-.263**
Attitude to computers	Primary	.018	.136**	.126**		-.071**	-.043*	.068**
	Secondary	-.051*	.228**	.196**		-.152**	-.081**	.053*
View of progression	Primary	-.030	-.015	.034	-.071**		.071**	-.053*
	Secondary	-.005	-.059**	.011	-.152**		.059**	-.057**
Enjoyment of school	Primary	.318**	-.319**	-.303**	-.043*	.071**		.393**
	Secondary	.455**	-.423**	-.368**	-.081**	.059**		.401**
Enjoyment of schoolwork	Primary	.166**	-.159**	-.215**	.068**	-.053*	.393**	
	Secondary	.294**	-.204**	-.263**	.053*	-.057**	.401**	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

As expected, some of the attitudes measured are associated, and most of these associations persist from primary to secondary school. In particular, the enjoyment of science is strongly related to the enjoyment of school and schoolwork, in both years 6 and 7. Indeed, all of the attitudes to science are related to attitudes to school.

One interpretation of this observation is that the school has an important influence on children's attitudes to individual subjects. This interpretation is supported by the literature (for example, Garverick, 1964; Keeves, 1975; Keys, 1987; Simpson and Oliver, 1990), and also by the findings of the earlier longitudinal study by Hadden (1981), who suggested that individual schools had an effect on the changes in science attitudes. If this interpretation is accepted, then the school effect must be taken into account when investigating science attitudes[1].

However, an alternative explanation should also be considered. The 'school enjoyment' scale asked about school in general, but the questionnaires were completed during science lessons. So, it is possible that the children's responses might have been coloured by their attitude to science lessons. If this were the case, then the 'enjoyment of school' scale might represent yet another aspect of children's attitude to science, and should be interpreted in that context. In consequence, the regression analyses would exclude enjoyment of school as a predictor variable, and this could affect the significance of the other variables in the analysis. This possibility was examined by performing all the regression analyses both with and without attitudes to school as predictor variables. In both

[1] This study has controlled for school attitudes in two ways: first in this chapter by the use of partial correlation coefficients and second, in Chapters 5 and 7 by using regression analysis to control for school attitudes and school structural variables.

sets of analyses the significant predictor variables were identical - except that, in one set attitudes to school could not appear as significant factors. Thus, this second interpretation of the high correlations between science and school attitudes does not affect the significance of other variables.

So, the interpretation of ‘attitudes to school’ remains unclear, and the present data alone cannot resolve the issue. However, since the literature suggests that there is a relationship between school attitudes and science attitudes, for the purposes of this discussion, it will be assumed that the children’s scores on the attitude to school sub-scales represent their *school* attitudes rather than their *science* attitudes.

Since the science attitude variables are so strongly related to attitudes to school, simple bivariate correlations cannot be expected to provide reliable estimates of the strengths of the relationships between these variables. The results of a second analysis, controlling for attitudes to school, using partial correlation coefficients are presented in Table 4-6, below.

Table 4-6: Partial correlations between attitude scores on the children’s questionnaire.

Partial correlation coefficients	**Sector**	**Enjoyment of science**	**Difficulty of science**	**Difficulty of science writing**	**Attitude to computers**	**View of progression**
Enjoyment of science	Primary		-.2672**	-.1318**	.0295	-.0518*
	Secondary		-.2499**	-.0876**	-.0288	-.0242
Difficulty of science	Primary	-.2672**		.3373**	.1331**	.0047
	Secondary	-.2499**		.3780**	.2195**	-.0412
Difficulty of science writing	Primary	-.1318**	.3373**		.1306**	.0492*
	Secondary	-.0876**	.3780**		.1951**	.0229
Attitude to computers	Primary	.0295	.1331**	.1306**		-.0607**
	Secondary	-.0288	.2194**	.1951**		-.1414**
View of progression	Primary	-.0518*	.0047	.0492*	-.0607	
	Secondary	-.0242	-.0412	.0229	-.1414**	

N.B. Controlling for attitudes to school and schoolwork

When Tables 4-5 and 4-6 are compared it is apparent that controlling for attitudes to school has important effects. Some relationships become much weaker, for example, attitudes to the use of computers appeared to be significantly related to enjoyment of science when bivariate correlation coefficients are used, but this relationship becomes insignificant when partial correlation coefficients are calculated.

The difficulties of science and of written work in science both remain significantly related to the enjoyment of science. It has been suggested that children find science hard because of the high level of abstraction and lack of relevance (Johnstone, 1991; Millar, 1991). The difficulty of science is also significantly related to the difficulty of written work in science, children having least difficulty with written work also having least difficulty with science. As discussed earlier (page 203) the items in the written work sub-scale asked about understanding the *why* and *how* of experimental work, and since both refer to difficulties encountered during science lessons, it might be expected that these two scales would be related.

The significant relationship between these two 'difficulties' scales and the use of computers indicates that computers are more likely to be regarded as helpful by children who find science difficult. Interviews with children in years 6 and 7 revealed that one of the reasons children were positive about using computers in science was that they thought it would reduce the amount of written work involved. It is also possible that a greater use of pictorial and diagrammatic representation when using computers assists those with weaker writing skills.

The data also suggests that perceptions of continuity and progression are *not significantly related* to the other attitudes to science lessons. This finding seems to be contrary to common beliefs; it is often held that one of the reasons for negative attitudes to school science is that there is too much repetition of earlier work (see pages 50-51 above). However, research by Sutherland (1996) supports the view presented here, and the present research finds further evidence in support of this position in the children 's written comments (see pages 380-381 in Chapter 6).

In summary, enjoyment of science appears to be strongly related to enjoyment of school and attitude to schoolwork. It also seems to depend upon the perception of the difficulties associated with science and the written work in science. Written work difficulties may be related to the practical task of writing or to the conceptual difficulties inherent in the written work.

The use of attitude structures, which combine to form an overall attitude (see page 54, Chapter 2), appears to be justified in view of the very close links between these sub-scales. It was expected that attitude sub-scales would be closely related if such an approach were appropriate. However, perceptions of continuity and progression were not significantly related to enjoyment of science in year seven and there were only weak associations in year six. Thus, the issue of the repetition of previous work and ideas does not seem to affect this sample of children's attitude to science. The use of computers, although not significantly related to enjoyment of science, was significantly associated with difficulty of science and difficulty of written work, for both years six and seven. Therefore, use of computers in science may be an important but separate issue, using computers may make science seem less difficult, and this may improve motivation for some children.

Regarding attitude to science as being a structure of attitudes, which includes three of the science attitude sub-scales, appears to be justified in view of the high correlation coefficients between them. However, use of computers and perceptions of continuity and progression cannot justifiably be considered as part of this 'attitude to science' structure, since neither is significantly correlated with all science attitude sub-scales; although use of computers may have a valuable place in science education and should be considered separately.

Finally, the close relationship between school attitudes and science attitudes should be regarded as an indication that there are some general, non-science issues that may have an important part to play in the development of attitudes to science. Such issues might include the socio-economic background of the school and individual school structures. These issues are dealt with via the regression analysis in Chapter 5. Also, unless attitudes to science are examined in the context of attitudes to school, the results obtained may not be very meaningful.

4.2.2.1 THE RELATIONSHIP BETWEEN CLASSROOM ACTIVITIES AND ATTITUDES

The relationships between children's attitudes to science and their perceptions of the frequency of classroom activities are set out in Table 4-7 below, using partial correlation coefficients, controlling for attitudes to school. These correlation coefficients indicate that children's enjoyment of science is significantly related only to the frequency of collaborative work. The more discussion and small-group activities that take place, the more likely are children to enjoy science lessons. This association is stronger at secondary school than at primary school.

Table 4-7: Partial correlations between attitudes and activity scores

Partial correlation coefficients	Sector	Collaborative	Standardised	Student directed	Teacher directed
Enjoyment of science	Primary	.0813*	.0319	.0106	-.0218
	Secondary	.2289**	-.0285	.0096	-.0262
Difficulty of science	Primary	-.039	-.0242	-.0826*	.0068
	Secondary	-.0654*	.0501	.0310	.0812*
Difficulty of science writing	Primary	.0039	-.0070	.0040	.0256
	Secondary	-.0248	.0118	-.0029	.0245
Attitude to computers	Primary	.0922**	.1169**	.1223**	.1531**
	Secondary	.0950**	.1633**	.0989**	.0889**
View of progression	Primary	-.039	-.1261**	.1226**	-.0743*
	Secondary	-.0274	-.0962**	-.1013**	-.0575

N.B. Controlling for attitudes to school and schoolwork

At secondary school the difficulty of science is also significantly related to the frequency of collaborative work, but the relationship is a negative one: children who express greater difficulty with science are likely to be those who experience less frequent use of collaborative work. On the other hand, greater use of teacher directed work is significantly associated with difficulty with science. These findings suggest that, at secondary school, students may experience more difficulty with science if teacher directed activities are more frequent and collaborative activities are less frequent. Furthermore, children at primary school appear likely to have more difficulty with science if the frequency of student directed activity is **higher**.

However, the statistical significance is not high for any of these correlation coefficients, and, in this analysis, only attitude to school has been taken into account. Since the remaining science attitude factors have fairly low reliabilities and all of the activities factors (except collaborative learning) have quite low reliabilities, the remaining correlation coefficients are unlikely to be very meaningful; particularly when there has been little control of variables. The effects of these variables, after controlling for school and teacher variables will be investigated in Chapter 5.

4.2.3 SUMMARY

The attitudes to science items, produced five factors: enjoyment of science, the difficulty of science, the difficulty of written work in science, attitude to computers in science, perceptions of progression and continuity in science. Attitudes to schoolwork changed only slightly on transfer, and results suggest that some children may find secondary school work easier than primary school work, but the changes are very small.

Enjoyment of school scores suggest that in the final year of primary school the majority of these children are very positive about school, but there is a group who seem to have quite negative views at both primary and secondary school. Enjoyment of school declines after transfer. At primary level attitudes to using computers in science lessons were very positive, but attitudes declined dramatically on transfer. It is suggested that lack of use of computers in science lessons may be responsible for this change. Furthermore, the majority regarded the work in science as challenging. These figures did not change appreciably after transfer to secondary school.

There appears to be more small-group practical work at secondary school, but less independent practical work, and greater use of teacher demonstration. At primary school the extent to which children felt that they had some control of their science activities was notable.

Tests appeared to be common in secondary school, but the proportions of children at primary and secondary school who often had tests were quite similar. In primary school group discussions, teacher discussions and group work were the norm, only a very small proportion of children said that they never worked in a group or discussed in a group or with the teacher. At secondary school most of the children in this sample were frequently engaged in small group practical work, but less often in discussion.

A comparison of the mean values for enjoyment of science in years six and seven shows that children at the end of primary school have a very positive attitude to science, which then declines slightly *after* transfer to secondary school.

However, this comparison does not take account of the changes in children's enjoyment of school. Furthermore, average scores on the difficulty of written work in science, *increase* significantly on transfer, suggesting that these children may find written work in science *less difficult after transfer.* Enjoyment of science appears to be strongly related to enjoyment of school and attitude to schoolwork. It also seems to depend upon the perception of the difficulties associated with science and the written work in science.

Attitude to science should be regarded as a structure of attitudes, which includes three of the science attitude sub-scales, and the close relationship between school attitudes and science attitudes should be regarded as an indication that there are some general, non-science issues that may have an important part to play in the development of attitudes to science. The correlation coefficients indicate that children's enjoyment of science is significantly related only to the frequency of collaborative work. The more discussion and small-group activities that take place, the more likely are children to enjoy science lessons. This association is stronger at secondary school than at primary school. However, greater use of teacher directed work is significantly associated with greater difficulty with science.

4.3 A comparison of the schools in each sector

Pearson's correlation coefficients were calculated for the numerical data from schools and are shown in Tables 4-8 and 4-9. It is notable that there is a high correlation between both primary and secondary schools' examination success and the percentage of children in those schools taking free school meals.

Table 4-8: Pearson correlation coefficients for primary school structural data

	Free school meals %	Number on roll	Level 4 or above in 1996 SATs tests %	Special needs %	Year 6 roll
Free school meals %		.121	-.447**	.453**	.244*
Number on roll	.121		-.046	-.071	.743**
Level 4 or above in 1996 SATs tests %	-.447**	-.046		.265*	-.203
Special needs%	.453**	-.071	-.265		.215
Year 6 roll	.244*	.743**	-.203*	.215	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 4-9: Pearson correlation coefficients for secondary school structural data

	5 or more A-C grades %	1 or more A-G grades %	5 or more A-G grades %	Authorised absence %	Unauthorised absence %	Free school meals %	Special needs %	School roll	Year 7 intake
5 or more A-G grades %		0.63**	0.77**	-0.70**	-0.43*	-0.76**	-0.62**	0.21	-0.19
1 or more A-G grades %	0.63**		0.91**	-0.65**	-0.28	-0.59**	-0.33	0.23	-0.03
5 or more A-C grades %	0.77**	0.91**		-0.73**	-0.22	-0.64**	-0.46*	0.22	-0.02
Authorised absence %	-0.70**	-0.65**	-0.73**		0.09	0.73**	0.41*	-0.25	-0.01
Unauthorised absence %	-0.43*	-0.28	-0.22	0.09		0.32	0.11	-0.10	0.00
Free school meals %	-0.76**	-0.59**	-0.64**	0.73**	0.32		0.54**	-0.37*	-0.04
Special needs %	-0.62**	-0.33	-0.46*	0.41*	0.11	0.54**		-0.29	-0.05
School roll	0.21	0.23	0.22	-0.25	-0.10	-0.37*	-0.29		0.77**
Year 7 intake	-0.19	-0.03	-0.02	-0.01	0.00	-0.04	-0.05	0.77**	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

These findings indicate that the examination success of a school may be more closely related to the socio-economic status of the area than to within-school effects. However, there are indications that primary schools may have a greater influence on their pupils' academic success since the correlation is much less pronounced at primary level. These relationships are shown on page 224, below (Figures 4-12 and 4-13).

Tables 4-20 and 4-21 also indicate significant relationships between the proportion of children with special needs, free school meals and examination results. These three related data sets (free school meals, examination results and proportion of children with special needs) could therefore all be regarded as providing information about the social background of the schools. Schools with high levels of free school meals and high proportions of children with special needs, and with poor levels of achievement are likely to be in areas of high social deprivation (Kelly, 1996; Gibson & Asthana, 1998; Howarth et al, 1998).

Figure 4-12: Relationship between primary schools' end of key stage 2 test results and free school meals

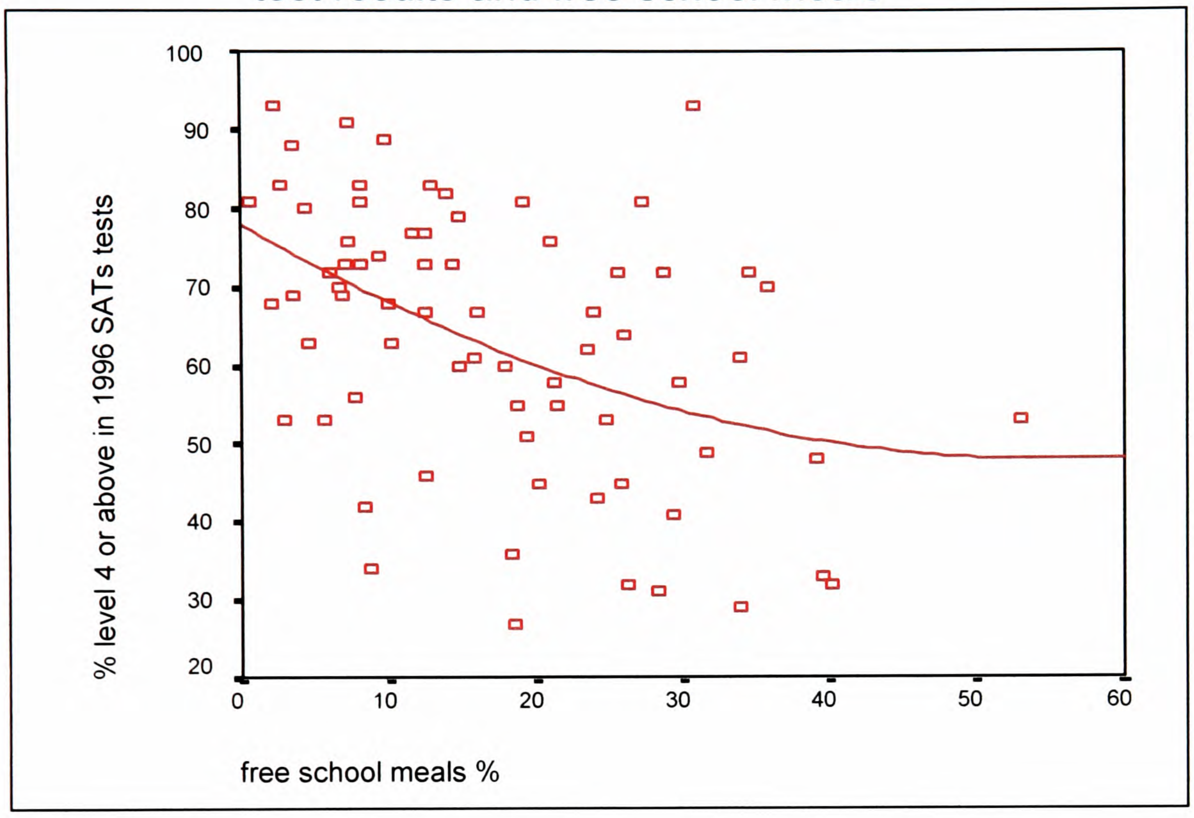
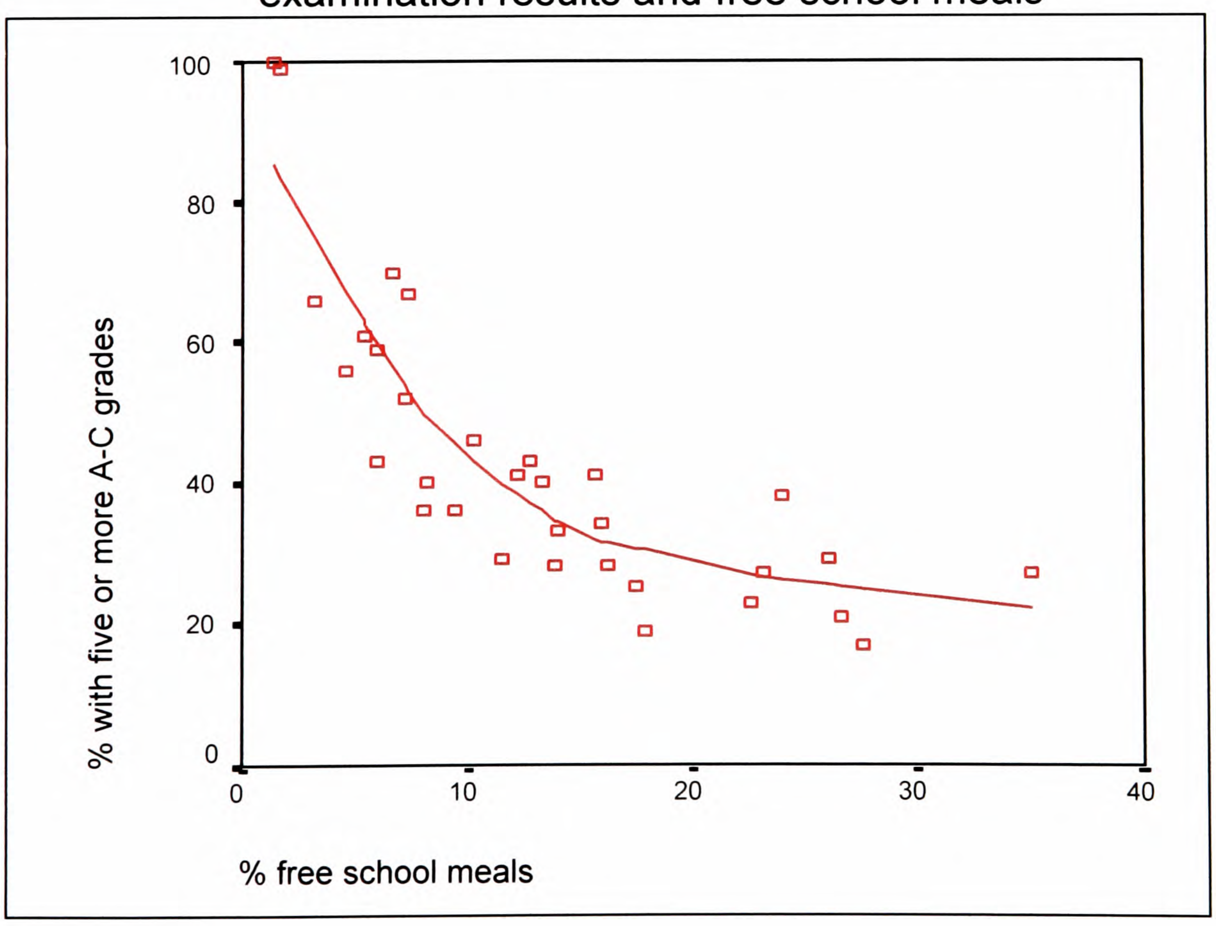


Figure 4-13: Relationship between secondary schools' GCSE examination results and free school meals



4.3.1 SCHOOLS DATA FROM INTERVIEWS

Information concerning teaching approaches and views of transfer arrangements was obtained from interviews with head teachers, heads of science, and science co-ordinators. In addition, at secondary schools, information about ability grouping and schemes of work was obtained.

4.3.1.1 TEACHING APPROACHES

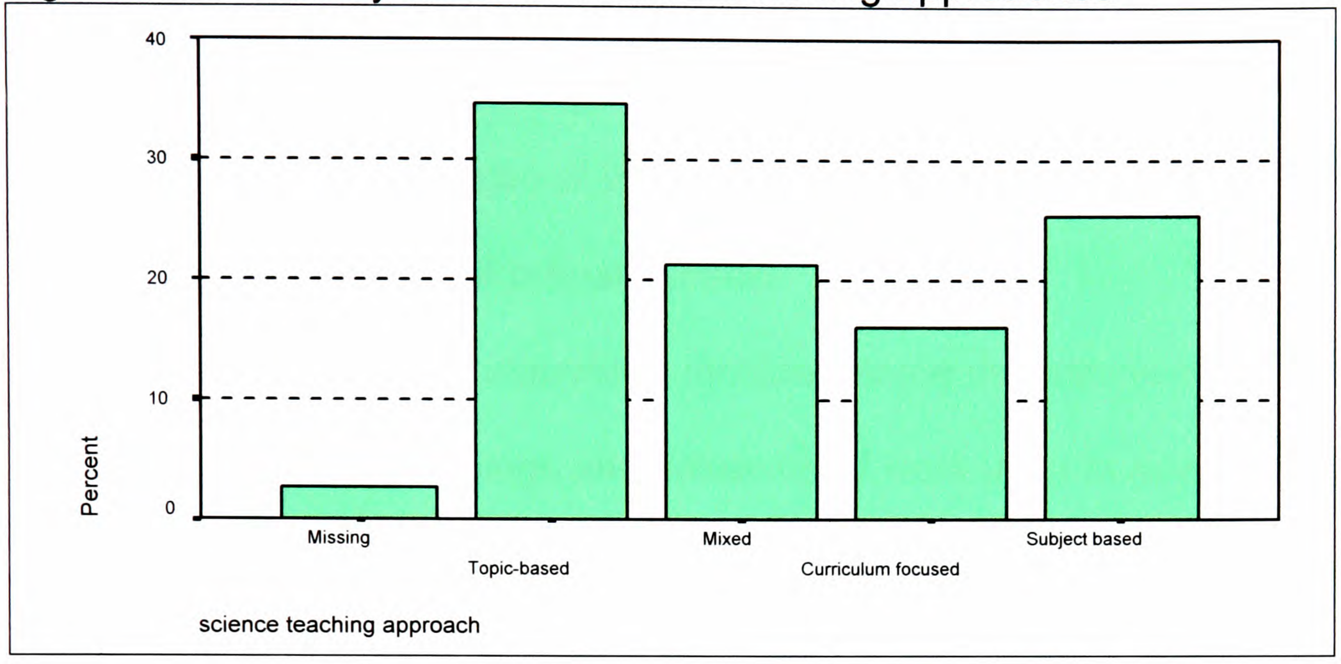
Science teaching approaches varied from school to school but they could reasonably be classified as follows:

Primary school	Secondary school
• Topic-based approach	• Integrated science
• Subject-based approach	• Co-ordinated science
• Curriculum focused approach	• Separate sciences.
• Mixed approach.	

At primary school, in the topic-based approach all curriculum work was related to the chosen topic, and no curriculum area was taught separately. At the opposite extreme, in the subject-based approach, curriculum subjects were time-tabled and taught as separate subjects. The two other approaches fell between these extremes; some schools said they used the topic approach but that they also included ‘mini-topics’ specifically for science from time to time when they couldn’t fit the necessary science into the topic naturally; this approach is described as the mixed approach. Finally, there were some schools using a ‘curriculum focused’ approach; topics were based on particular curriculum areas. For example: ‘the topic at the moment is geography based “Our place in the world” and won’t include much science, we will do a science topic later’ and another ‘the topic now is “Energy is the go of things” it’s a science-led topic’.

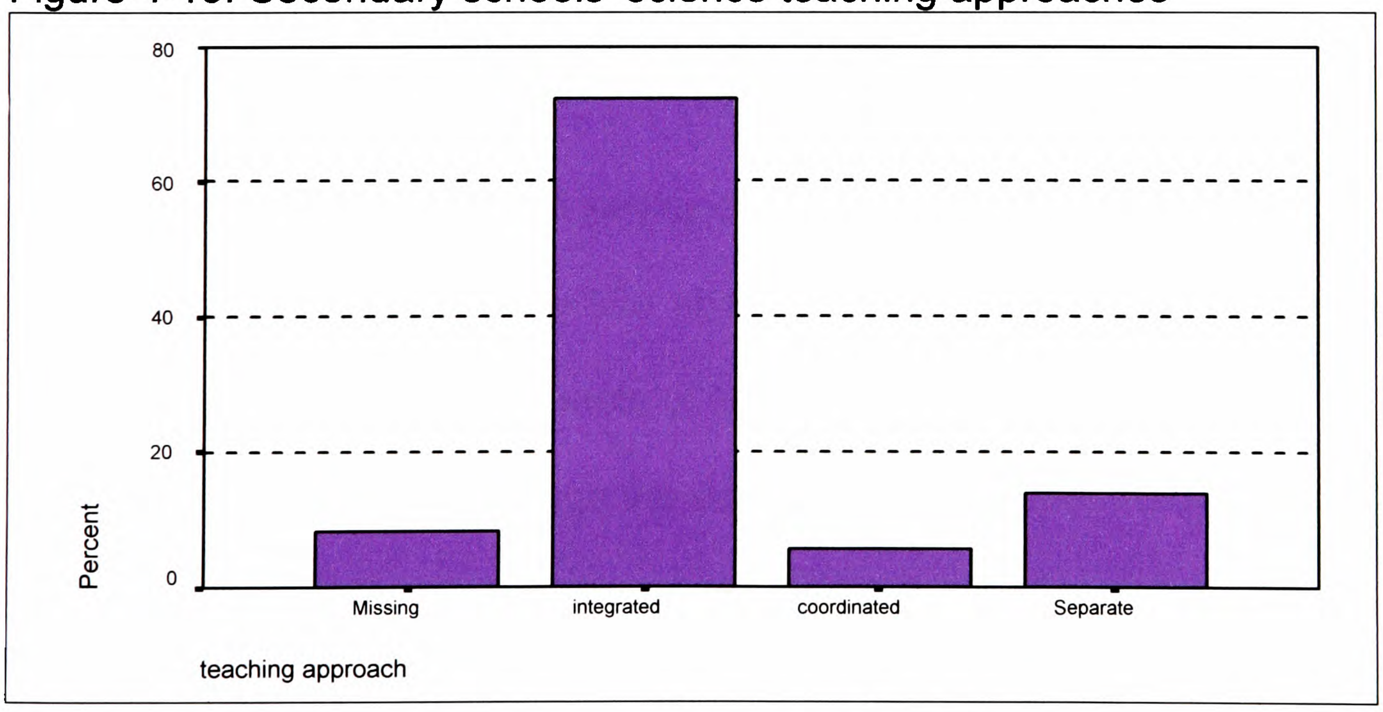
Most primary schools used a topic-based approach, but there were also a large number of schools using a subject-based approach (Figure 4-14).

Figure 4-14: Primary schools' science teaching approaches



Such an approach where science lessons are written into a timetable is closer to the secondary school model than is the topic approach. Therefore using this approach might reduce transfer difficulties in science. Most secondary schools were using an integrated science approach, a few taught separate science but a co-ordinated approach was rarely used (Figure 4-15).

Figure 4-15: Secondary schools' science teaching approaches



The effect on children of transferring from say, a topic approach at primary school to separate sciences at secondary school might be different from a transfer from a primary subject-based approach to a secondary integrated science course. Children who already see science as a separate subject may have different attitudes on transfer from those used to a 'topic' approach. However, no significant differences in attitudes to science were found at either primary or secondary school for groups of children who experienced different teaching approaches for science at primary school[1]

Secondary school interviews included some discussion of the Head of Science policy, the groupings and schemes of work used in science.
Some heads of science were very flexible, allowing staff to teach in whatever way they liked and using any materials they wished, and at the other end of the spectrum, there were heads of science who insisted that the agreed scheme of work was followed exactly, using the materials specified.

There were various approaches to the organisation of teaching groups; some were specific to the science department, for example, mixed-ability teaching, setting and banding, but others were general school policy, for example one school taught all lessons in single-sex groups, and other schools had selective intakes.

Secondary schools used a variety of schemes of work, some of which were designed to encourage a particular approach: the Salters scheme emphasises technological and societal aspects of science and the CASE scheme has a set of activities designed to encourage the development of pupils 'thinking skills'. Although the majority of schools used a text-book led approach about a third of all

[1] Kruskal Wallis test for enjoyment of science by primary science teaching approach

	Enjoyment of science in Y6	Enjoyment of science in Y7
Chi-Square	7.249	2.122
df	3	3
Asymp. Sig.	.064	.547

schools used largely in-house scheme, with their own work sheets supported by a variety of text-books. Certain schemes of work were particularly popular; a number of schools using the Salters scheme, Spotlight Science and the CASE scheme (see Table 4-10).

Table 4-10: Secondary schools' teaching approaches

Science scheme of work			CASE
	n	%	n
Own	11	31.4	1
Spotlight science	6	17.1	1
Starting science	5	14.3	
Salters	4	11.4	
Science now	2	5.7	1
Science at work	1	2.9	
Active science	1	2.9	
Q science	1	2.9	
Science companions	1	2.9	
Understanding science	1	2.9	
Ginn	1	2.9	1
Oxford science	1	2.9	

4.3.1.2 Transfer and liaison procedures

Transfer procedures and perceptions of liaison were addressed through interviews; three questions were asked:

- What arrangements are there for pupils to get to know the staff and to experience the school in general before they join year 7?
- Will pupils have had any experience of the science department before joining year 7?
- How do you feel about these liaison arrangements?

There appeared to be differences in the perceptions of transfer and liaison procedures between the primary and secondary participants. As Table 4-11 below shows, most of the primary heads and primary science co-ordinators were quite satisfied with the links they had with secondary schools, only three schools expressed dissatisfaction.

In primary school interviews the focus of comment was on pastoral links and adjustment to secondary school. Specific links in science were not often mentioned and when discussed the emphasis was on borrowing equipment, children having experienced science lessons in the secondary schools, or secondary teachers coming and helping with science lessons at primary schools. The transfer of information and records in specific curriculum areas was not mentioned.

Table 4-11: Primary teachers' views of liaison with secondary schools

Primary views of liaison procedures	**Count**	**%**
Poor	3	4.17
Average	8	11.11
Good	38	52.78
Very good	23	31.94
Total	72	

However, although secondary heads of science all mentioned a range of liaison activities that were in place within their school, they then went on to talk about curriculum collaboration between primary and secondary schools, and the transfer information about pupils. As can be seen in Table 4-12 most secondary heads of science were not satisfied with the transfer *information* they received.

Table 4-12: Secondary teachers' views of liaison with primary schools

Secondary heads of science views transfer information	**Count**	**%**
Not used or not available	23	69.70
Some use	9	27.27
Very useful	1	3.03
Total	33	

These findings are supported by those of Schagen and Kerr (1997); this apparent lack of transfer information may hinder curricular progression. These differences seem to stem from the very different foci in the two sectors. Primary schools focussed on the social or pastoral aspects of the transfer process but secondary science departments focussed on the curriculum and the abilities of the pupils.

Interviews demonstrated how science departments varied in the amount of time and effort they put into liaison with the primary schools and in the emphasis their departments placed on the gathering and dissemination of transfer information about the new intake. Some schools collected and used as much transfer information as possible, others emphasised the induction procedures while others devoted much time to liaison with the primary schools. Whole school approaches to induction were also found to vary markedly in terms of the amount of time given over to induction procedures for the new intake. Two examples are given below, which illustrate the worst and the best of the relationships between the primary and secondary science departments in this survey.

Example 1:Two primary schools, Crooklands and Holycroft, send the majority of their children to Highfields secondary school.

The head at Crooklands said:

All children have a taster day in the middle of September and then Highfields do a road-show for parents. Teachers visit children in the summer. No other links – we use their minibus. I would like to have more links with the secondary schools to improve continuity and progression at 11 in the curriculum. The secondary schools seem to have difficulty organising differentiated work and so there is a lack of progression for the more able. Secondary teachers need to meet us and be in the primary schools more. Year 7 is almost a wasted year.

The deputy head at Holycroft said:

The links with Highfields are not good in science or in general. They used to come in to do PE and music but cut-backs have stopped this. Children don't go there except for [taster] *days. There are not really any staff links, maybe the occasional informal link, via requests from primary staff. There are no Heads' meetings.*
It used to have a terrible reputation but it has got better. It is a caring school and is good on special needs.

Both of these teachers appear to take a reactive rather than a pro-active approach. The liaison is poor because the secondary school has stopped doing things. The other noteworthy points are: (a) the lack of any specific comment about science (the nature of the research had been explained, and these teachers were aware that the focus was on science); and (b) the lack of comment about the transfer of pupil information.

The head of science at Highfields said:

The school has taster days in October for everybody but they always do some science and some IT. There is an open day about two weeks later – mid-October. Staff who deal with liaison go to the primary schools (Head of Year and Deputy Head). There is also a road show but its probably going to be dropped. There are no induction days.Transfer information/ documents are not very satisfactory. We take children from about 13 primary schools and some are better than others at transferring records and information. We have asked for SATs levels and teacher assessment levels, but nothing comes quite often. We mainly get tick sheets based on the programme of studies, but we are not sure whether pupils have covered the work or achieved it. No levels come at present. We test the children in the first two weeks using NFER tests.

This secondary head of science also appears to takes a reactive rather than a pro-active approach. The tone of these comments suggests a lack of interest in the liaison activities. The other noteworthy points are: the lack of any specific comment about visiting or talking with the primary schools, and the emphasis on the transfer of pupil records, particularly achievement levels, and the lack of trust in the primary assessments (use of own testing procedures after transfer).

At both primary and secondary levels there is a distinct lack of interest in what happens in the other school, and an emphasis on the other school providing a particular service. The primary schools want secondary teachers to come in and take lessons, provide assistance. The secondary schools want the primary schools to give them detailed records of pupil progress and achievement. There is no sense of recognition that each needs to know what the other is doing.

Example 2: at the other end of the spectrum is a partnership where all the school agreed that liaison was excellent. Riverside, The Abbey and Parrish primary schools send the majority of their children to The Kingfisher secondary school

In the Riverside school, the science co-ordinator expressed satisfaction with the links.

We have very good links. Most of our children go there. The secondary school gives us a lot of help with our science day. There are also individual staff links, and very good relationships between the staff at the primary and secondary schools. There are lots of visits to the secondary school by both y5 & y6 children, for example there are regular contacts with the drama department who put on performances in the primary school. The children also visit the secondary school frequently. The schools work together. There are good special needs links. We have very good relationships.

The head teacher of The Abbey school was also very happy about liaison in general, but suggested that in science links might not be quite as good as they used to be:

Most of our children go to The Kingfisher (about 95%). We have pretty good links. There are heads' meetings and heads of departments meet as well, although some departments are stronger than others. There are good induction visits , one morning for all children with lots of different activities. There are also a couple of other occasions during the year when children go there. Teachers from the secondary school come here to talk to the children. Science links are not as good as they used to be, there used to be an egg race but not now. They have got a new head of science.

Parrish school head mentioned all the above activities and also commented that:

... there are year 5 induction visits now. Special needs department is very good, the head of that department does a lot of liaison work.

The head of science at The Kingfisher had this to say about liaison with the primary schools.

We have induction in summer term, 1 morning or afternoon - they look round with Y7. There's an activities morning in autumn term (they choose their activities). A member of staff has done talks on different aspects of science to some of primary schools. One or two of science staff go to some of primary schools (at the primary schools' request). Sometimes there are contacts to use equipment - but not frequent.

How do you feel about liaison arrangements?

Big issues are time and what is to be achieved from meetings. Originally I felt that primary schools wanted information and help from us, but this has changed and now the primary schools are being more constructive and trying to move forward. Staff involvements are important. No overall set aims for science liaison from our senior management, more so for pastoral liaison. Would like more, but we have limited time. Would like KS2 examination results, but the teacher assessment and information isn't very useful.

Within this group of schools the tone of the responses is positive, and there is a sense of teachers from both sectors meeting and talking together. The secondary head of science believes that there is more constructive work going on but still talks about the transfer of examination results as the important issue. Similarly, although there is a strong sense of satisfaction among the primary school comments, there is still an emphasis on the secondary science staff providing input.

These observations suggest that teachers in the two sectors have very different perceptions of the liaison process: primary teachers believe that the main aim of the liaison process is to provide pastoral support for the children, whereas the secondary science teachers seem to regard transfer of pupil information as the main aim of the process. This is supported by the findings of Lee, Harris & Dickson (1995) and the House of Commons Education Committee report (1995), both of which have indicated differences in perceptions within the two sectors.

4.3.2 Relationships between school level variables

Spearman's rank order correlation coefficients were calculated to establish the existence of any important relationships within the interview level data.

4.3.2.1 Primary schools

At primary school the teaching approach used and the liaison with secondary schools were found to be unrelated (Table 4-13).

Table 4-13: Primary school correlations between interview level data

Spearman's rank order correlations	Levels of liaison	Science teaching approach
Levels of liaison	1.0000	0.2311
Science teaching approach	0.2311	1.0000

Associations between interview level data and numerical data were investigated using Pearson's correlation coefficients and the results of these calculations are shown in Table 4-14 below. As before, asterisks indicate significant associations.

Table 4-14: Primary school correlations between interview and descriptive data

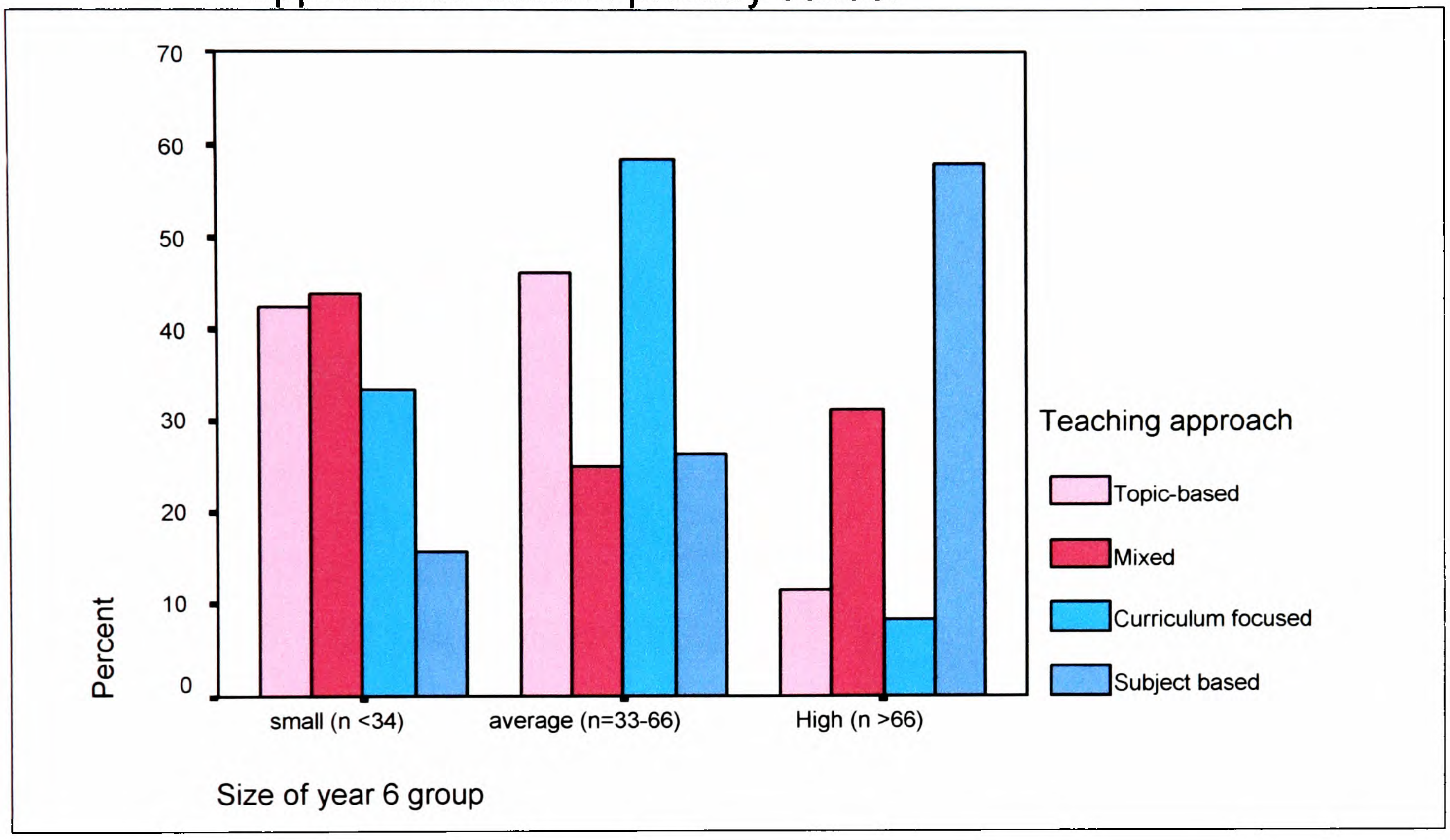
Spearman's rank order correlations	Science teaching approach	Levels of liaison
Science teaching approach	1.000	.231
Levels of liaison	.231	1.000
Free school meals %	.026	-.056
Number on roll	.105	-.023
% level 4 or above in 1996 SATs tests	.021	-.150
% children with special educational needs	.171	.050
Year 6 roll	.290*	-.109

* Correlation is significant at the .05 level (2-tailed).

** Correlation is significant at the .01 level (2-tailed).

There was only one significant relationship in the primary schools data, and that was between the number of pupils enrolled in year 6 and the teaching approach used (Figure 4-16).

Figure 4-16: The relationship between the size of year 6 roll and the teaching approaches used in primary school



This may simply reflect a greater flexibility within large primary schools. Having more staff and rooms available may allow these schools to have a subject-based timetable. Certainly interviews indicated that many head teachers felt that greater degree of timetabling would be the only way to deal with the changes in the amount of subject material since the advent of the National Curriculum. However, it might be thought to reflect a difference in perception of teaching roles in small and large schools.

4.3.2.2 Secondary schools

To investigate the possibility of any important relationships within the secondary school interview level data Spearman's rank order correlation coefficients were calculated. Table 4-15 gives the results of these calculations. It is apparent that the significant relationships are between aspects of the transfer process. The schools that make use of the results of Key Stage 2 tests also group by ability in some way, suggesting that the test results may play a part in determining the make-up of such groups. But where primary teachers' assessments are available secondary schools are likely to use mixed ability grouping.

Table 4-15: Correlations between secondary school interview level data

Spearman rank order correlation coefficients	Teaching approach	Ability grouping	Head of science policy	Scheme of work	CASE used	Timetable time for liaison	Number of induction sessions	Key stage test results available	Key stage test results used	Teacher assessment available	Teacher assessment used	Use of transfer information
Teaching approach		0.0975	0.0852	-0.3836	0.0000	0.1217	-0.1314	0.0622	0.0000	-0.5146**	-0.0491	0.0105
Ability grouping	0.0975		-0.1758	0.1165	0.0956	-0.4714	-0.1695	-0.0094	0.4377*	-0.4001*	-0.2485	0.2525
Head of science policy	0.0852	-0.1758		-0.1619	-0.3364	0.3913	0.2062	-0.0936	-0.1892	-0.2746	0.1229	0.0643
Scheme of work	-0.3836	0.1165	-0.1619		0.0817	-0.1141	-0.2581	-0.2689	0.1388	-0.0063	-0.0495	0.0704
CASE used	0	0.0956	-0.3364	0.0817		-0.3043	0.1190	0.2041	0.0244	-0.0439	-0.2182	-0.1770
Timetable time for liaison	0.1217	-0.4714	0.3913	-0.1141	-0.3043		-0.0828	-0.1111	-0.3333	-0.0304	-0.1250	-0.2854
Number of induction sessions	-0.1314	-0.1695	0.2062	-0.2581	0.1190	-0.0828		0.0292	0.3985	0.0341	0.3342	0.5396*
Key stage test results available	0.0622	-0.0094	-0.0936	-0.2689	0.2041	-0.1111	0.0292		0.3486	-0.0731	-0.1550	0.1739
Key stage test results used	0	0.4377*	-0.1892	0.1388	0.0244	-0.3333	0.3985	0.3486		-0.2526	-0.1992	0.6521**
Teacher assessment available	-0.5146**	-0.4001*	-0.2746	-0.0063	-0.0439	-0.0304	0.0341	-0.0731	-0.2526		0.1111	-0.2319
Teacher assessment used	-0.0491	-0.2485	0.1229	-0.0495	-0.2182	-0.1250	0.3342	-0.1550	-0.1992	0.1111		0.6001**
Use of transfer information	0.0105	0.2525	0.0643	0.0704	-0.1770	-0.2854	0.5396*	0.1739	0.6521**	-0.2319	0.6001**	

* Correlation is significant at the .05 level (2-tailed).

** Correlation is significant at the .01 level (2-tailed).

The very strong association between the availability of key stage test results, teacher assessments and use of transfer information would be expected; if no such information was available then it could not be made use of. However the strong link between the length of the induction process and the use of transfer information is perhaps of some interest; where schools say they make use of transfer information they also tend to have a longer period of induction for children. These relationships suggest that schools may be using information from the primary schools for two distinct purposes: to assist in organising ability groups, and to facilitate the transfer procedure for the children.

Where appropriate Pearson's correlation coefficients were calculated to establish relationships between numerical and non-numerical data, the results of these calculations are shown in Table 4-16 below.

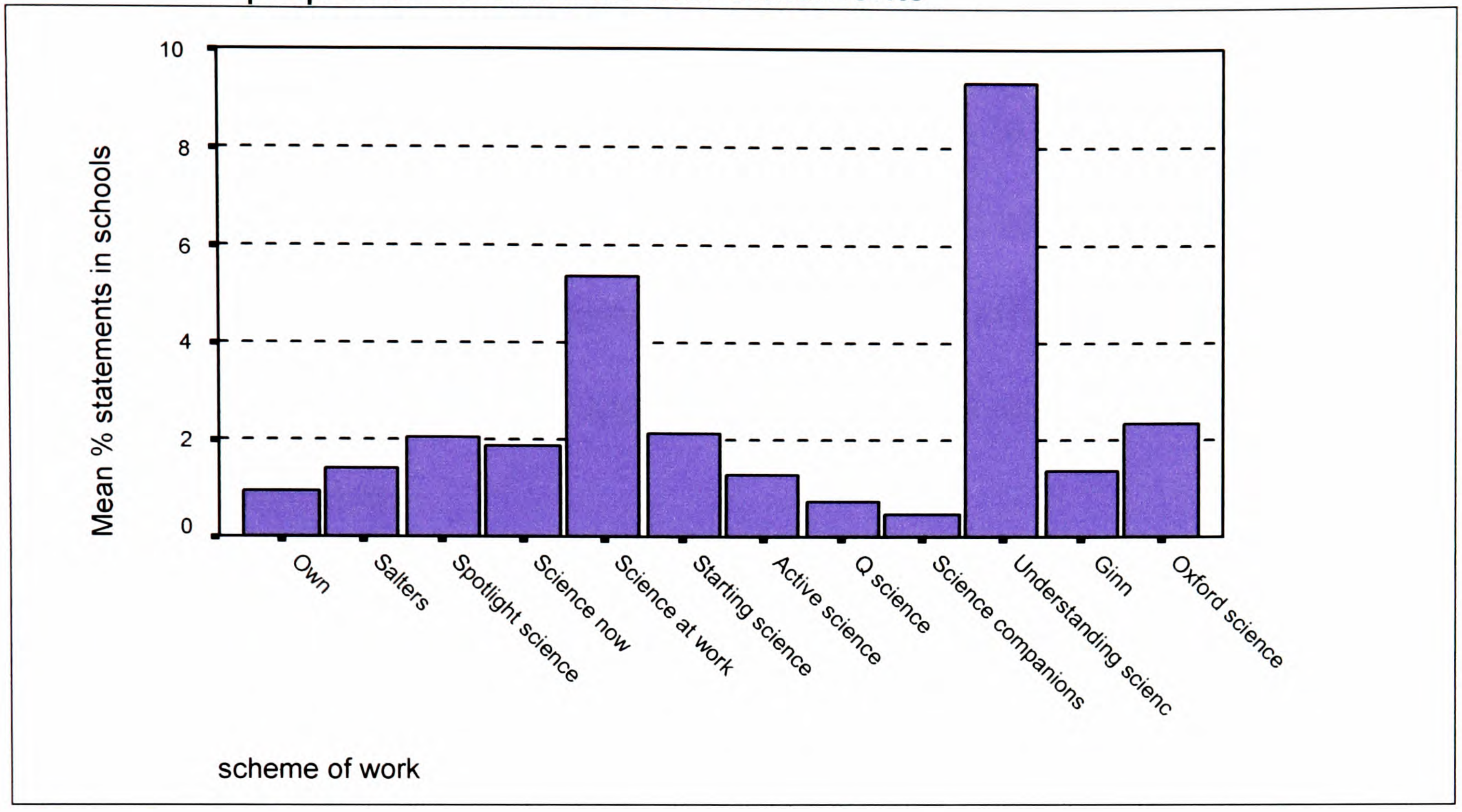
Table 4-16: Correlations between secondary school variables and interview data

Pearson's product moment correlation coefficients	% with five or more A-C grades	One or more A-G grades	% with five or more A-G grades	Authorised absences %	Unauthorised absences %	% with special needs	% with statements	Free school meals %	Roll	Year 7 roll
Ability grouping	-0.0868	-0.2926	-0.2624	0.2633	-0.1765	0.1297	-0.1503	0.1546	0.2050	0.2998
Head of science policy	0.2913	0.0349	0.1282	-0.1004	-0.3281	0.0263	-0.0613	-0.2905	-0.2123	-0.3849
CASE used	-0.1219	0.0728	0.0587	0.0639	0.2237	0.2230	0.0404	0.1608	0.1631	0.0561
Number of induction sessions	-0.3256	-0.4704**	-0.4414*	0.3226	0.1112	0.0447	-0.0965	0.3304	-0.1682	-0.0577
Key stage test results available	-0.1647	-0.2764	-0.1528	0.0071	0.1944	0.0240	-0.2807	0.1091	0.0750	0.2144
Key stage test results used	-0.1527	-0.3086	-0.2283	0.2305	0.0387	-0.1414	-0.0649	0.0618	0.1228	0.3877
Scheme of work	0.0084	0.1467	0.1280	0.0723	-0.0227	0.1084	0.3684*	-0.1577	-0.0719	-0.0509
Teacher assessments available	-0.1216	0.2106	0.2012	0.0356	0.2397	0.1068	0.1297	0.1875	-0.0425	-0.0006
Teacher assessments used	-0.1689	0.0052	-0.0494	0.0209	-0.0421	0.2101	0.0421	0.0004	-0.1449	-0.0015
Teaching approach	0.2267	0.0998	0.1160	-0.3080	-0.1000	-0.2147	-0.2867	-0.1325	0.0932	0.0552
Timetable time for liaison	-0.1281	0.0433	0.1191	0.2064	-0.1930	0.1587	0.2239	0.1280	-0.3117	-0.1694
Use of transfer information	-0.2556	-0.2736	-0.2396	0.1983	-0.0368	0.0391	0.0001	0.0245	0.0282	0.3199

The schools' policies on induction appear to be linked with their academic success; more induction time being given by schools with lower proportion of examination passes at GCSE (statistically significant at $p<0.05$).

However, individual science departmental policy does not seem to be linked with the school's academic record or its socio-economic background. The only significant relationship found is between the chosen scheme of work and the proportion of children with statements. Where schools have a high proportion of children with statements of special needs they seem more likely to choose schemes such as 'Understanding science' or 'science at work' than say 'Science companions' (Figure 4-17, overleaf).

Figure 4-17: Relationship between secondary school schemes of work and proportion of children with statements



It is interesting that the use of the CASE scheme is not related to any of the chosen indicators. Since it is claimed to have a positive effect on achievement schools where achievement levels were low might have used it. On the other hand, it has been suggested by the authors of the CASE scheme, that the scheme is unsuitable for less able children, and so, here again, one might expect a link with academic achievement within a school.

The lack of any other significant relationships might suggest that science departments do not take into account the socio-economic background of their pupils when making decisions about ability groupings and their use of transfer information.

Teacher assessments are not taken into account in schools with higher levels of disadvantage or when deciding about ability groups. However, the data derived was from a small number of interviews and so lack of or presence of statistical significance may not be very meaningful – particularly at that level ($p<0.5$). It may be that setting/ ability grouping was a school level policy and heads of department actions and feelings would not be expected to necessarily relate to it in that case. Or perhaps teacher assessments were not passed on to heads of department.

The use of the CASE scheme does not appear to be related to any of the measured school variables, suggesting that the CASE scheme is *not* adopted by schools with specific intake problems (e.g. high deprivation, low academic performance). The head of department policy was not significantly related to any other school variable.

4.3.3 Summary

Although the majority of primary schools were small and the secondary schools were larger, the survey included some very large primary schools with school rolls in excess of 500, and some very small secondary schools with rolls of less than 600. School size appeared to be related to teaching approaches in primary school. Since larger schools have more staff and rooms available these schools have the flexibility to introduce a subject-based timetable. The subject-based approach was introduced by many of the primary head teachers to cope with the more subject-based demands of the National Curriculum.

The significant relationships between the proportion of children with special needs, free school meals and examination results, indicated that all of these variables provided information about the socio-economic background of the schools.

There were various approaches to the organisation of teaching groups; some were specific to the science department, for example, mixed-ability teaching, setting and banding, but others were general school policy, for example one school taught all lessons in single-sex groups, and other schools had selective intakes. Most secondary schools used an integrated science approach, a few taught separate science but a co-ordinated approach was rarely used. The choice of teaching approach was not generally related to any of the measured variables, although science departments using an integrated science course were likely to have primary teacher assessments available.

Certain schemes of work were particularly popular, a number of schools used Salters, Spotlight Science and the CASE scheme, but there were no important associations within the data to suggest why particular schemes had been chosen. However, there were indications that schools with a high proportion of children with statements of special needs were more likely to choose particular text-books such as 'Understanding science' or 'science at work', which may suggest some consideration of the children's needs. Schools did not adopt their own tailor-made scheme of work when they had large proportions of children with statements; in fact the opposite seems to be more usual. The Head of Science policy did not appear to be related to any other school variable. The use of the CASE scheme was not closely related to any of the school indicators and it seems that science departments had chosen the CASE scheme for reasons that were unconnected with school structural variables.

Schools in areas of greater deprivation tended to provide longer periods for induction of the new intake, but individual science departmental policy does not seem to be strongly linked with the school's socio-economic background

Primary heads, on the whole, were quite satisfied with the liaison arrangements between primary and secondary schools. Primary schools focused on pastoral links and adjustment to secondary school, and specific links in science were not often mentioned. However, secondary heads of science were less satisfied with transfer arrangements and stressed different aspects of the transfer process, in particular collaborative curriculum links, and record transfer These differences suggest a difference in perception of the relevance of the liaison process between primary and secondary teachers.

4.4 The teachers' questionnaire

The profiles of the primary and secondary teachers in this study were obtained by the use of the *same* questionnaire for both sectors. The questionnaire was divided into four parts: first biographical, dealing with qualifications and experience, second teaching approaches, third personal views of science, and fourth a free-response section. Parts two and three consisted of Likert-type items.

4.4.1 Biographical profiles

Differences between the sectors, in terms of the number and level of science qualifications and in the proportions of male and female teachers, were as anticipated (DFEE, 1997). Almost one third of the primary teachers responding were male (Table 4 -17). This is a much higher proportion of male teachers than the average for primary schools[1], but it is common to find a higher concentration of male teachers teaching year six classes (for example, Association of Teachers and Lecturers, 1998; Thornton & Bricheno, 2000) and all the children in the primary school survey were in year six classes.

Table 4-17: Numbers and proportions of male and female teachers in the survey.

Gender	**Primary**		**Secondary science**	
	n	%	n	%
Male	41	29.5	115	60.5
Female	98	70.5	75	39.5
Total	139		190	

[1] DfEE statistics suggest that the proportions overall are about 20% male and 80% female (DfEE 1997)

When general qualifications were compared, secondary teachers, in general, had higher qualifications (Table 4-18).

Table 4-18: Range of qualifications, for primary and secondary school teachers.

Highest qualification	**Primary**		**Secondary science**	
	n	%	n	%
GCSE/GCE	5	3.6	1	.5
A-levels	4	2.9	3	1.6
Subject diploma	4	2.9	4	2.1
Certificate/diploma education	29	21.0	2	1.0
Degree	83	60.1	162	84.8
Higher degree	13	9.4	19	9.9

However, almost two thirds of the primary school teachers had degrees and most of the remaining third had a teaching diploma with only a small proportion having no formal teaching qualifications, and a similar proportion of those teaching in secondary school also held no formal teaching qualification.

Inspection of the highest science qualifications held reveals, as might be expected, that primary school teachers were less well qualified in the *sciences* than the comparison group of *specialist science* teachers at secondary school (Table 4-19).

Table 4-19: Range of science qualifications, for primary and secondary teachers.

	Primary		**Secondary science**	
Highest science qualification	n	%	n	%
None	33	23.91	0	0
GCE/GCSE	72	52.17	3	1.57
A Levels	12	8.70	12	6.28
B Ed	12	8.70	14	7.33
Degree	8	5.80	144	75.39
Higher degree	1	0.72	18	9.42

In terms of the range of science subjects, very few primary teachers had physical science qualifications at any level (8%) whereas almost 50% of secondary teachers held physical science degrees (Table 4-20). These results are very similar to those produced in a recent large-scale survey of science teachers (Council for Science and Technology, 2000).

Table 4-20: Science subjects at highest levels studied by teachers

Science subject studied to highest level	Primary teachers				Secondary teachers			
	None beyond school		University level		None beyond school		University level	
	n	%	n	%	n	%	n	%
Physics	2	1.7	1	4.8	0	0	35	20.2
Chemistry/Biochemistry	3	2.6	5	23.8	3	20.0	55	31.8
Biological	7	6.0	10	47.6	5	33.3	76	43.9
Geology	1	.9	3	14.3	0	0	2	1.2
General science	72	61.5	2	9.5	7	46.7	4	2.3
None	32	27.4	0	0	0	0	0	0
Total	117	100.0	21	100.0	15	100.0	173	100.0

There were also differences between primary and secondary teachers' INSET experiences (Table 4-21). Although primary teachers in general lacked science qualifications, they received little science INSET in comparison with their secondary colleagues. Almost 14% of secondary teachers had received science INSET training, in excess of 4 days over the last 5 years, but only 4% of the primary teachers had received similar amounts of training in the last 5 years. Science INSET of less than 4 days was common among secondary teachers (56%), but only 23% of primary teachers had obtained similar amounts of training.

A small number of primary teachers had been on the 20-day science course for science co-ordinators, but this number constitutes only 4% of the 139 primary teachers surveyed. The introduction of Primary Science as part of the National Curriculum occurred 10 years ago, but during the second half of that decade, 70% of the primary teachers surveyed have received *no* science INSET. Interviews with primary teachers showed that many had received no science training in the previous 5 years either.

Table 4-21: In-service training received in the previous 5 years by teachers

In-service training over the last 5 years	Primary				Secondary science			
	No science at university		University science		No science at university		University science	
	n	%	n	%	n	%	n	%
Science - 20 days	3	2.6	3	14.3	0	0	0	0
Science - 10 days	3	2.6	1	4.8	0	0	7	4.2
Science - 5 -9 days	2	1.7	0	0	1	6.7	18	10.7
Science - 4 days or less	27	23.5	4	19.0	7	46.7	96	57.1
Other training	61	53.0	6	28.6	5	33.3	30	17.9
None	19	16.5	7	33.3	2	13.3	17	10.1
Total	115	100.0	21	100.0	15	100.0	168	100.0

These findings concerning gender, qualifications and training are much as anticipated and are well documented elsewhere (for example, DfEE, 1999), indicating that this sample of teachers is not untypical of the general population of teachers. Therefore, their approaches to science teaching and their views about science are also likely to reflect those of other primary and secondary teachers.

4.4.2 APPROACHES TO SCIENCE TEACHING

In this section, Likert-type items were used to ask teachers to rate certain approaches to teaching science as 'very important', 'quite important', not important' or 'irrelevant'. The majority of teachers responded to all of these items, and there were very few missing responses. These responses are summarised in Table 4-22 overleaf.

Table 4-22: Responses to section two of the teachers' questionnaire

	Questionnaire items	Sig.	Sector	n	Very important %	Quite important %	Not important %	Irrelevant %	No response n
12	Making the connections between science, technology and society	ns	Primary	136	46.32	50.74	2.94		3
			Secondary	189	56.61	40.74	2.65		2
13	Showing that science knowledge is tentative and changing	ns	Primary	135	31.11	57.78	10.37	0.74	4
			Secondary	186	25.81	63.44	10.75		5
15	Providing opportunities for discussions of children's own scientific ideas	**	Primary	138	76.09	23.91			1
			Secondary	191	56.02	42.41	1.57		0
16	Passing on scientific knowledge	**	Primary	136	37.50	60.29	2.21		3
			Secondary	191	68.59	30.89	0.52		0
17	Selecting topics and activities which the children will enjoy	*	Primary	135	65.93	32.59	0.74	0.74	4
			Secondary	190	55.79	39.47	2.63	1.58	1
18	Using time to study applications of scientific concepts	ns	Primary	135	25.19	62.96	10.37	1.48	4
			Secondary	188	26.06	69.15	4.79		3
19	Supplementing the curriculum with challenging problems	ns	Primary	137	30.66	59.85	9.49		2
			Secondary	189	24.87	65.08	10.05		2
20	Using the curriculum content to illustrate the processes of science	ns	Primary	134	35.07	55.22	8.21	1.49	5
			Secondary	188	38.30	57.45	3.19	1.06	3
21	Ensuring sound knowledge of theoretical concepts and principles	**	Primary	137	25.55	54.74	18.98	0.73	2
			Secondary	190	64.74	33.16	2.11		1
22	Helping children to construct their own explanatory models	ns	Primary	137	45.26	46.72	6.57	1.46	2
			Secondary	191	41.88	49.21	8.38	0.52	0
23	Providing experimental results and information which explain the natural world	*	Primary	136	32.35	58.09	8.09	1.47	3
			Secondary	189	43.92	50.79	5.29		2
24	Illustrating that scientific knowledge is objective and true	ns	Primary	134	23.13	50.75	22.39	3.73	5
			Secondary	186	18.28	60.22	13.98	7.53	5
25	Matching materials to students level of ability	ns	Primary	138	88.41	10.14	1.45		1
			Secondary	191	86.39	13.61			0
26	Supplementing the curriculum with more detailed information	*	Primary	136	13.97	55.88	25.74	4.41	3
			Secondary	190	15.26	70.00	13.16	1.58	1

N.B. For primary teachers n=139, for secondary teachers n=191.
** Significant at the 0.01 level (2-tailed).
* Significant at the 0.05 level (2-tailed).

The differences between responses on some items seemed quite large and so Mann-Whitney tests were carried out to look for any statistically significant differences. The results of these tests, summarised in Table 4-22, indicate some significant differences between primary and secondary teachers' responses to these items. Primary teachers were significantly more likely to agree that 'Providing opportunities for discussions of children's own scientific ideas' and 'Selecting topics and activities which the children will enjoy' were very important, but secondary teachers were significantly more likely to agree that 'Ensuring sound knowledge of theoretical concepts and principles' and 'Passing on scientific knowledge' were very important. Such differences would seem to reflect the different concerns of teachers in the two sectors; the more child-oriented primary approach, (for example, Bloom, 1989; Abell & Smith, 1994; Hayes & Johnston, 1995; Murcia & Schibeci, 1999), and the more subject-oriented secondary approach (for example, Spear, 1988).

The teachers' responses to these items concerning their approaches to science teaching were subjected to factor analysis to establish groups of items relating to single constructs (see Appendix 5). The four factors to emerge are thought to relate to the following constructs:

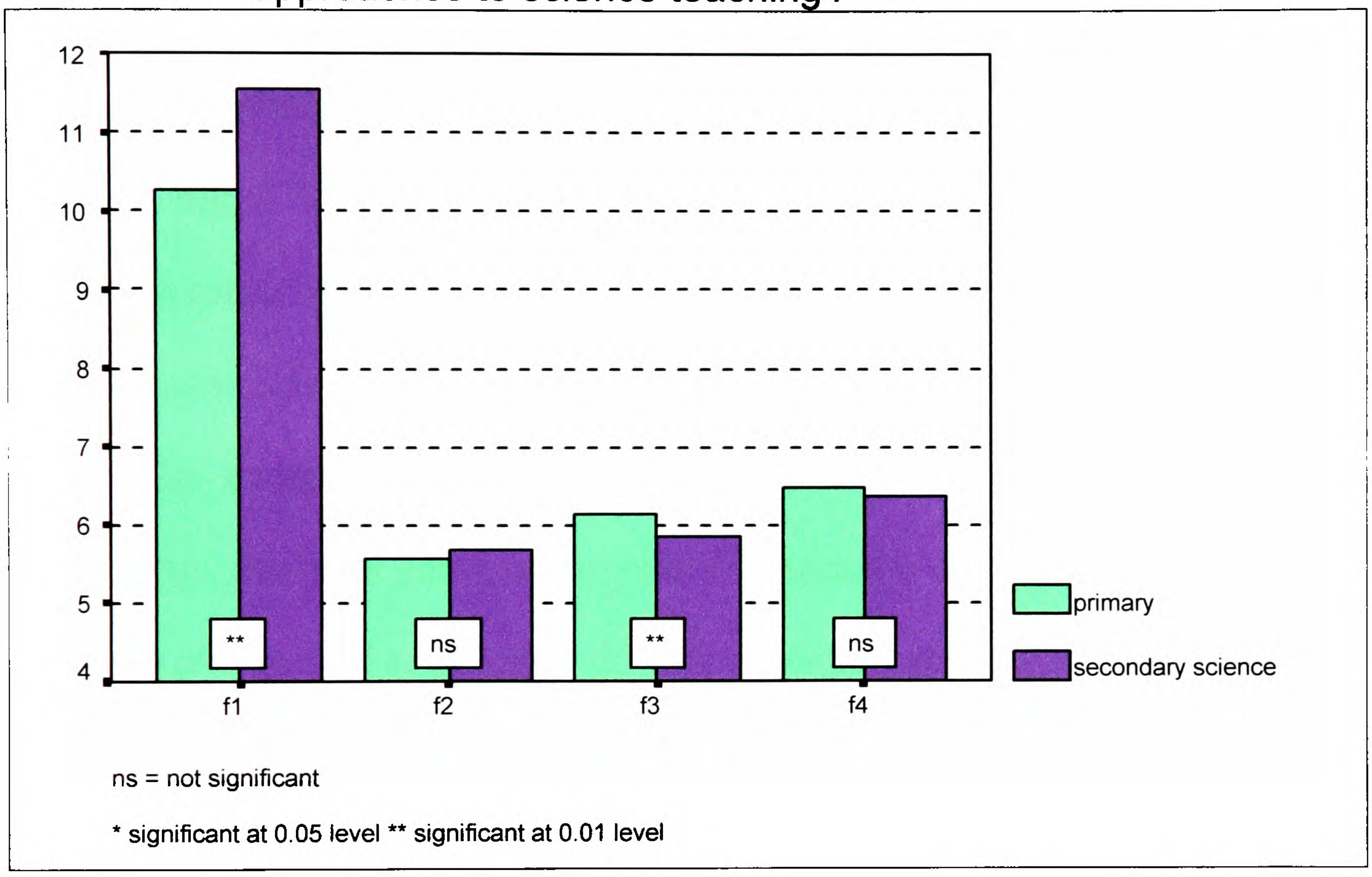
- The transmission of science as a body of factual knowledge (f1)
- Highlighting the links between science, society and technology (f2)
- The use of child-centred discussion (f3)
- The use of motivating approaches (f4)

The average scores for primary and secondary teachers on each of the sub-scales are shown in Figure 4-18 overleaf, and significant differences between the two groups of teachers are also indicated, again Mann-Whitney tests were used.

Similar views were held by primary and secondary teachers concerning the links between science, society and technology (f2) and the use of motivating techniques (f4) For this sample of teachers these two approaches were unrelated to their teaching sector, science qualifications, gender or years of teaching experience (either inside or outside the classroom).

Such similarities suggest that, in these areas, teaching approaches were unlikely to result from teaching in one particular sector. Perhaps personal differences and experiences or particular emphases within certain schools are involved in shaping such views, but these areas are outside the scope of this study.

Figure 4-18: A comparison of primary and secondary teachers' scores on 'approaches to science teaching'.



The significant areas of difference between primary and secondary teachers were in the level of importance attached to the transmission of science as a body of knowledge (f1) and the use of child-centred discussion (f3). The majority of teachers at primary school felt that the transmission of scientific knowledge was not important, but most secondary school teachers regarded it as very important. These differences may reflect the very different general emphases within the two sectors, but it could also reflect the difference in subject specialisms reflected by the two sectors. Pre-service science teachers have been found to favour a more didactic style of teaching than their peers (Bennett and Turner-Bissett ,1993), and Science specialists to place a greater emphasis on knowledge of content than history teachers (Donnelly, 1999); English, history and geography are particularly common subject specialisms among primary teachers (Thornton, 1999).

4.4.3 VIEWS OF SCIENCE

The frequencies of responses by primary and secondary teachers are given in Table 4-23, below. The most striking feature of this table is the difference in the numbers of missing responses for primary and secondary teachers: primary teachers had a far higher proportion of missing responses. But the overall response rates from primary and secondary school teachers were very similar and the response rates for the items in Section 2 of the questionnaire were also similar. So, it seems likely that there is something important about the observed differences. Perhaps some of the primary teachers were not able to respond because of a lack of knowledge or understanding about science, or because they had not been interested enough in science to develop their own views about the nature of science.

Nevertheless, they were as likely as the secondary teachers to respond to the items about process and content. The process-content debate is one that has engaged interest and debate in both sectors for a number of years, and so primary teachers have had the opportunity to consider the issues. Therefore, it may be that it is lack of opportunity to debate and consider these issues rather than lack of knowledge, understanding and interest, which has caused the observed differences.

Table 4-23: Responses to section three of the teachers' questionnaire

		Sig.	Sector	Valid n	Strongly agree	Agree	Balanced view	Disagree	Strongly Disagree	No response
					%	%	%	%	%	n
V27	The object of scientific activity is to reveal reality	ns	Primary	120	5.83	33.33	48.33	10.83	1.67	19
			Secondary	169	7.10	40.83	40.24	9.47	2.37	22
V28	Scientists have no idea of the outcome of an experiment before they do it	*	Primary	136		1.47	24.26	56.62	17.65	3
			Secondary	189		3.70	15.87	47.62	32.80	2
V29	Scientific research is economically and politically determined	ns	Primary	129	21.71	46.51	20.93	8.53	2.33	10
			Secondary	187	22.99	50.80	20.32	5.35	0.53	4
V30	Science education should be more about the learning of scientific processes than the learning of scientific facts	**	Primary	135	30.37	44.44	20.74	3.70	0.74	4
			Secondary	188	13.30	35.11	34.57	13.83	3.19	3
V31	The way scientists work is independent of morals or ethics	**	Primary	128	1.56	13.28	24.22	46.09	14.84	11
			Secondary	187	2.14	6.42	13.90	49.20	28.34	4
V32	The most valuable part of a scientific education is what remains after the facts have been forgotten	*	Primary	122	23.77	40.98	21.31	12.30	1.64	17
			Secondary	170	15.88	37.65	25.88	15.88	4.71	21
V33	Scientific theories are valid if they work	ns	Primary	120	0.83	25.83	36.67	30.00	6.67	19
			Secondary	176	7.95	34.09	27.27	26.70	3.98	15
V34	New scientific knowledge is entirely the result of many new experiments and observations	ns	Primary	120	4.17	29.17	25.83	33.33	7.50	19
			Secondary	181	3.87	29.28	24.31	36.46	6.08	10
V35	There is no such thing as a true scientific theory	ns	Primary	86	4.65	27.91	32.56	29.07	5.81	53
			Secondary	164	10.98	25.61	27.44	28.66	7.32	27
V36	Human emotion plays no part in the creation of scientific knowledge	ns	Primary	121	1.65	9.09	9.92	61.98	17.36	18
			Secondary	180	1.11	5.00	14.44	57.22	22.22	11
V37	Scientific theories describe a real external world which is independent of human perception	ns	Primary	100	1.00	13.00	23.00	51.00	12.00	39
			Secondary	165	1.82	16.36	23.03	36.36	22.42	26
V38	Practical experience is not essential for the acquisition of scientific knowledge	ns	Primary	135	1.48	15.56	21.48	34.81	26.67	4
			Secondary	188	2.13	22.87	13.83	30.32	30.85	3
V39	Scientific theories have changed over time simply because experimental techniques have improved	ns	Primary	126	3.97	28.57	27.78	32.54	7.14	13
			Secondary	185	3.78	26.49	24.86	35.68	9.19	6
V40	'Scientific method' is transferable from one scientific investigation to another	**	Primary	130	8.46	71.54	16.92	2.31	0.77	9
			Secondary	180	23.89	62.78	10.56	2.78		11
V41	Scientists decide between theories purely by looking carefully at the results of experiments	ns	Primary	103	3.88	9.71	35.92	45.63	4.85	36
			Secondary	181	2.21	19.34	28.18	45.30	4.97	10
V42	Scientific theories are as much a product of imagination and intuition as inference from experimental results	**	Primary	122	6.56	33.61	31.97	22.13	5.74	17
			Secondary	184	16.30	47.83	18.48	13.04	4.35	7
V43	Scientific knowledge is different from other kinds of knowledge in that it is more objective	ns	Primary	127	1.57	30.71	33.86	28.35	5.51	12
			Secondary	180	4.44	36.11	31.67	22.22	5.56	11
V44	There are certain physical events in the universe which science can never explain	**	Primary	127	22.05	38.58	22.05	13.39	3.94	12
			Secondary	179	16.20	30.17	20.11	21.79	11.73	12
V45	Scientific knowledge is morally neutral – only the application of the knowledge is ethically determined	ns	Primary	118	6.78	49.15	20.34	18.64	5.08	21
			Secondary	173	13.87	42.77	15.61	20.81	6.94	18
V46	All scientific experiments and observations are determined by existing theories	ns	Primary	117		22.22	25.64	43.59	8.55	22
			Secondary	183	1.09	14.21	18.03	51.37	15.30	8
V47	Science is special because of the methods and processes it uses	ns	Primary	118	9.32	33.90	33.05	19.49	4.24	21
			Secondary	171	7.60	43.86	26.90	19.30	2.34	20

N.B. For primary teachers n=139, for secondary teachers n=191.

** Significant at the 0.01 level (2-tailed).

* Significant at the 0.05 level (2-tailed).

T-tests suggest some statistically significant differences between the responses of teachers in the two sectors (indicated in by asterisks in Table 4-23). Three of the items on which primary and secondary teachers have significantly different views concerned their feelings about the processes of science (items 30, 32 & 40). The majority of the primary teachers (75 %) felt that 'processes' were more important than 'facts' (item 30), but less than half of the secondary teachers (48%) took this view. A similar result was obtained for item 32, although views were less polarised; 65% of primary teachers and 54% of secondary teachers indicated that the facts were not particularly important. Item 40 suggests that scientific method is in some way special; only 9% of primary teachers but 24% of secondary science teachers agreed strongly with this view. These results indicate that these primary teachers are more likely than secondary teachers to regard process skills as more important than factual information and that they are less inclined to regard science as having any special status. Items 31 and 42 are also significantly different for primary and secondary teachers ($p<0.01$) and could be seen as representing aspects of a stereotypical 'science'.

31: The way scientists work is independent of morals or ethics

42: Scientific theories are as much a product of imagination and intuition as inference from experimental results

The responses of these teachers suggest that primary teachers are more likely to take this stereotypical view, 28% of primary teachers did not agree that scientific work needed to involve imagination and intuition, and 15% agreed that scientific work was independent of morals and ethics.

These differences suggest that primary and secondary teachers are likely to have very different views of science, and as will be seen in Section 4.4.4, page 254 the teachers' written comments about science and science teaching support this suggestion. These observations support those made by Vickery (1987) in a small study involving 66 teachers (from nursery, infant, junior and secondary schools) asking about the meaning of progression. Analysis of the text of their responses showed that primary teachers more often referred to process and secondary teachers to content.

The items concerning teachers' views about the nature of science were next subjected to factor analysis. This analysis turned out to be particularly difficult, and there is a distinct possibility that this whole section of the questionnaire lacks validity in view of the proportion of 'don't know', missing responses and associated negative comment about this section; the full details of this analysis are given in Appendix 5.

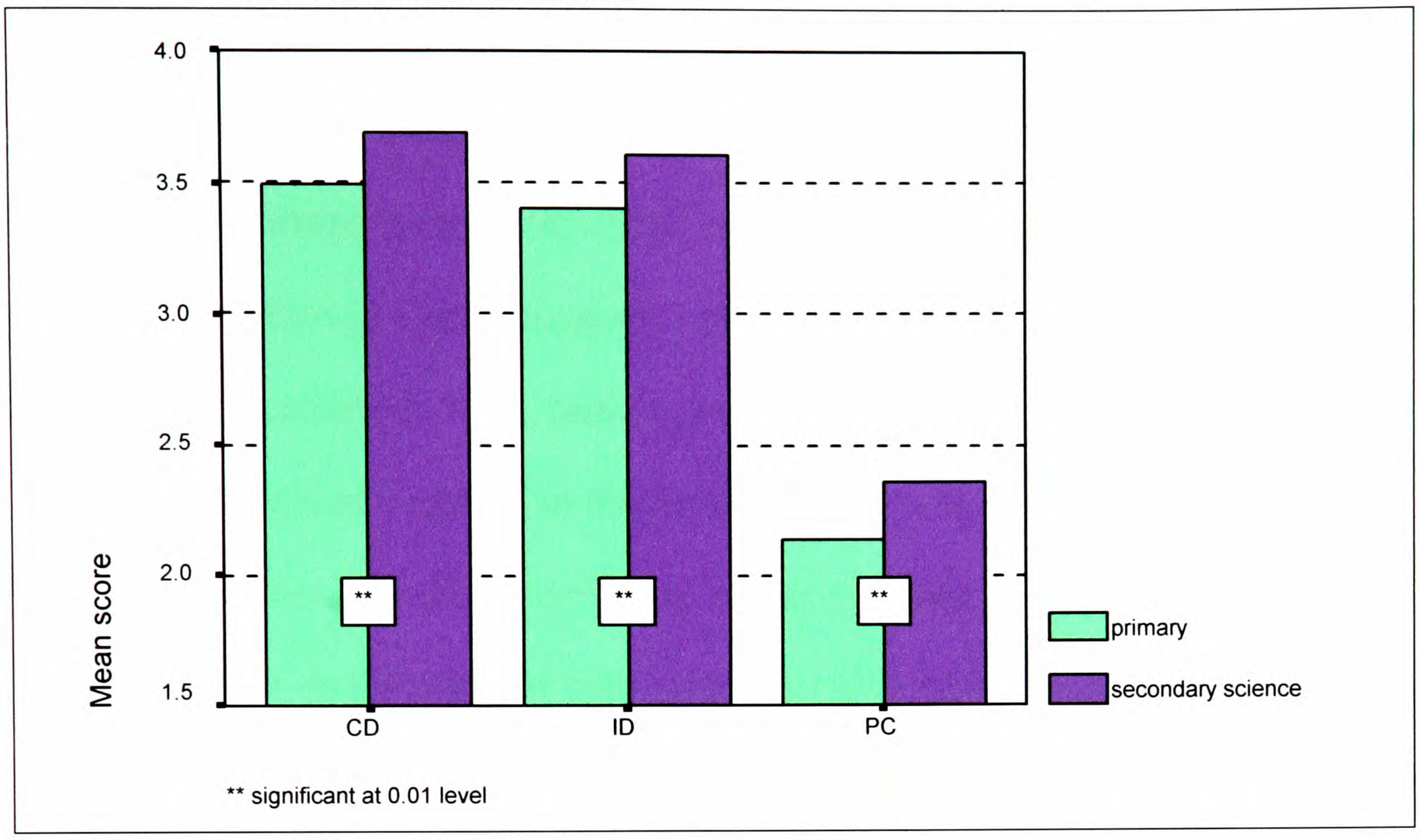
However, on the basis of this analysis, three new sub-scales were created, representing aspects of teachers' views about the Nature of Science. The final groups of uni-dimensional items being:

- contextualism-decontextualism (CD group): 31, 36 and 39
- inductivism-deductivism (ID group) : 28, 34 and 42
- process-content (PC group) : 30, 32 and 40

(The terms used above are defined in Appendix 1).

When the scores obtained on these factors are compared for primary and secondary teachers, using independent sample t-tests, the differences are statistically significant. These differences are represented in bar chart form in Figure 4-19, below.

Figure 4-19: A comparison of primary and secondary teachers' scores on 'the Nature of Science'.



For each factor the minimum score is 1 and the maximum is 5.

On the CD scale lower scores indicate a more de-contextual view, and higher scores indicate a more contextual view. The difference between primary and secondary teachers' views was statistically significant ($p<0.001$); secondary teachers are likely to hold more contextualist views about science than primary teachers. On the ID scale higher scores indicate a more deductive view, and lower scores indicate a more inductive view. The difference between primary and secondary teachers' views was statistically significant ($p<0.001$); secondary teachers are likely to hold more deductivist views about science than primary teachers. On the PC scale higher scores indicate a more content oriented view, lower scores indicate a more process-oriented view. The difference between primary and secondary teachers' views was found to be statistically significant ($p<0.001$), and secondary teachers are likely to hold more content oriented views about science than primary teachers.

These factors may not be valid, and they may not be reliable since they are based on a series of assumptions. If the validity and reliability were to be investigated by interviewing a large number of teachers from both sectors then it might be possible to improve on these factors. However, they are the best available at the moment, and their inclusion in further analysis may throw some light on issues, which would otherwise be excluded. Thus, bearing in mind the problems discussed above, these factors will be included in the analyses that follow.

These results indicate some particular differences between the teachers in the two sectors: in their stated approaches to science teaching and in their views about science, and, as in the previous section, these differences seem to reflect the preoccupations of the two sectors.

4.4.4 Written comments about science teaching

At the end of sections two and three there were spaces for teachers to add their own comments, and in each case there was a prompt, related to the section of Likert-type items. The prompts were as follows:

> At the end of the 'teaching approaches' section:
>
> *Please complete the following sentence to reflect your views on science teaching:*
>
> *'Teaching children about science ...'*
>
> At the end of the 'views about science' section:
>
> *Please complete the following sentence to reflect your view of science: 'Science is ...'*

The responses were transcribed and read through many times to allow familiarisation with the general nature of the responses before coding was undertaken. The written comments were then categorised by question and by teaching sector, and the text re-read within those categories. Although, as would be expected, there was a wide range of opinions, nevertheless there appeared to be particular differences between the two sectors.

In responding to 'Teaching children about science...' the most obvious differences were primary and secondary teachers' expressions of their feelings, and their views about what was important in science teaching. Tables 4-24 and 4-25 show simple numerical counts of these responses reflecting these differences. In all, 123 primary teachers and 163 secondary teachers made a written response, however, not everyone responded in both sections, and some teachers made more than one statement about a particular issue. Thus, the number of responses does not always correspond to the number of overall responses. The feelings expressed (Table 4-24) were either concerned with science teaching or with the Science National Curriculum.

Table 4-24:Teachers' feelings about teaching science: by teaching sector

	Primary N=123		**Secondary Science N=163**	
	n	%	N	%
Should be fun	14	11.38	27	16.56
Teacher enjoys	5	4.07	11	6.75
Positive	26	21.14	47	28.83
Interesting	0	0	4	2.45
Negative	23	18.70	8	4.91
Difficult	48	39.02	5	3.07
Demanding	42	34.15	0	0.00
The need to motivate pupils	10	8.13	22	13.50
National curriculum issues	11	8.94	10	6.13

It was heartening to find that a fair proportion of the primary teachers felt quite positive about science (21%), but the proportion expressing negative views was almost as high (19%). Furthermore, when those primary teachers expressing the view that science was difficult to teach were taken into account (39%), it was evident that many primary teachers had rather negative views of science. Some teachers expressed a lack of interest in science, for example,

> *90[1] ***Teaching children about science*** *is a challenge to me since my lack of expertise and personal interest make it difficult to enthuse and motivate myself and the children.*
> (female primary teacher)

Other teachers talked about their lack of knowledge, for example,

> *91 ***Teaching children about science****....is a challenge! I feel uncertain (personally) of certain concepts (related more to physics/chemistry) and therefore find it hard to "teach" these.*
> (female primary teacher)

> *135 ***Teaching children about science*** *is often difficult due to my own lack of scientific training.* (male primary teacher)

A few were particularly forthright, for example,

> *116 ***Teaching children about science*** *should be left to specialist Science teachers in the Secondary School. The Primary Curriculum is already overloaded, most Primary Teachers do not have the scientific knowledge and expertise to teach science adequately. Science is boring!* (female primary teacher)

Comments such as these illustrate clearly that for many of these primary school teachers lack of adequate subject knowledge often resulted in a negative attitude to teaching science and was also likely to restrict their ability to teach the required science curriculum.

In contrast, only 8 secondary teachers expressed any negative feelings (5%), and these were related to children's attitudes to learning science or to the imposition of additional workload, rather than to a negative attitude to the subject of science. The quotations below illustrate these feelings.

[1] *90 is the reference code for this teacher, this format is used throughout.

*143 ***Teaching children about science*** *is something I always wanted to do because, when I was at school my favourite subject was science. However in recent years, I have found it harder to motivate pupils when doing theoretical aspects of science. Pupils appear to want to do practical work and although they do learn from it, they do not enjoy writing it down or sharing their findings with others.* (male secondary science teacher)

*245 ***Teaching children about science*** *is challenging. Many pupils who come to us regard science as boring. Lessons have to be carefully planned and carried out that catch pupils' interest and can be related to everyday life.* (female secondary science teacher)

*129 *... the increasing demands on our time (due to assessment etc.) mean it is often difficult to fully exploit opportunities for, say, research or open-ended experimentation.*
(female secondary science teacher)

As well as expressing their feelings about teaching science, these teachers wrote extensively about various aspects of teaching science; the number and areas of comment on 'teaching children about science ...' are shown in Table 4-25, below.

Table 4-25: Skills mentioned in teaching science, categorised by teaching sector

Skills	**Primary N=123**		**Secondary Science N=163**	
	n	%	n	%
Investigating	41	33.33	12	7.36
Knowledge	17	13.82	39	23.93
Understanding	28	22.76	41	25.15
Questioning	33	26.83	14	8.59
Experimenting	31	25.20	33	20.25
Observing	23	18.70	11	6.75
Hypothesising	16	13.01	10	6.13
Concluding	16	13.01	4	2.45
Reporting	13	10.57	2	1.23
Just skills	12	9.76	13	7.98
Thinking	5	4.07	10	6.13
Discussing	4	3.25	3	1.84

Large numbers of teachers from both sectors said that teaching science should involve understanding (23% of primary teachers and 25% of secondary teachers) and experimental work (25% of primary and 20% of secondary teachers). But teachers from different sectors had very different views about *what* should be understood or what might be the *purpose* of experimental work. Primary teachers were more likely to talk about experimental work allowing the development of skills and an understanding of processes, as these comment illustrate,

> * 114 ***teaching children about science*** *...should engage them in practical, first hand experiences. Learning to behave as a scientist is as if not more important at this stage than learning facts.* (Female primary teacher).

> * 105 ***teaching children about science****.involves the first hand practical investigation of things concretely experienced by them and is concerned with the objects and situations of everyday life. It develops process skills and enables the children to develop an investigative mind with a scientific approach to solving problems.* (Female primary teacher).

Whereas secondary teachers were more likely to talk about experimental work being used to enhance understanding *and* knowledge.

> *86 *... is all about teaching them to understand the world in which they live, to give them the theoretical knowledge and understanding to solve problems (technology) and to design and evaluate experiments through which they can gain new knowledge or put their ideas to the test.* (Male secondary teacher).

> *106 *I believe pupils learn more if they can use practical work to form the basis of more academic work.* (Female secondary teacher).

Indeed, many primary teachers emphasised that knowledge was not important, but that skills and processes were what mattered in teaching science.

> * 60: ***teaching children about science*** *is primarily concerned with developing their abilities to examine, explore, investigate, record and understand the world about them. It should be based upon first hand experience, deal with things that are relevant to them. It should concentrate upon the processes of learning rather than the acquisition of facts.* (Male primary teacher).

* 78: ***teaching children about science*** *is about not teaching but allowing the children to discover. The teacher's role is to ensure that the children have the tools to plan and carry out their own investigations in order to test their predictions.* (Female primary teacher).

Comments such as these reflect the differences observed in teachers' scores on the knowledge factor (f1) and the child-centred factor (f3) described on page 247 above.

However, there were some teachers (13 primary and 9 secondary) said that *both* knowledge and experiment were important.

* 101: **teaching children about science** *is to give them the opportunities to develop skills, knowledge and understanding in this particular field through focused exploration and investigation in familiar contexts.* (Female primary teacher).

*150: **teaching children about science** *is about stimulating and motivating an inquiring attitude to the world about them through the exploration of ideas both theoretical and practical.* (Male secondary teacher).

There was a greater emphasis on a practically based approach among the primary teachers (see Table 4-26, below). More than one in three primary teachers (35%) expressed the view that teaching children about science should be practically based, whereas only just over one in ten secondary teachers (13%) expressed that view. Primary teachers were also more likely than secondary teachers to express the view that children should have more autonomy or independence in their learning. These two ideas were often linked, as in these typical examples:

*17: ***teaching children about science*** *means helping children to find out about something through their own actions and making some sense of the result through their own thinking.* (Female primary teacher).

*160: ***teaching children about science*** *is important but where possible children should learn through experience/experiment.* (Male primary teacher).

*126: ***teaching children about science*** *should give the children chance to discover for themselves. To try out their own theories and ideas experimentally.* (secondary teacher).

*27: ***teaching children about science*** *must be made enjoyable to ensure an understanding of the subject. It must also be taught at a level they understand and many of their ideas must be incorporated into lesson not just a right or wrong answer.* (secondary teacher).

Table 4-26: Views about teaching and learning science, by teaching sector

Teaching science	**Primary N=123**		**Secondary N=163**	
	n	%	n	%
Practically based	43	34.96	21	12.88
Knowledge based	24	19.51	35	21.47
Collaborative	5	4.07	2	1.23
Student autonomy	20	16.26	9	5.52
Teacher directed	5	4.07	17	10.43

Table 4-26 also reflects the tendency for secondary teachers to emphasise knowledge based learning (slightly more than primary teachers), and a more teacher-directed approach, giving the pupils a more passive role. This is reflected in the following examples,

*47 ***teaching children about science*** *...Teaching children is irrelevant. Teaching them to do it is relevant.* (Female secondary teacher).

56* ***teaching children about science* *allows them to share my knowledge* (Female secondary teacher).

*99 ***teaching children about science*** *is about informing them about the world they live in.* (Male secondary teacher).

Where primary teachers mentioned control or direction, the emphasis was on directing the pupils to be actively involved.

* 73: ***teaching children about science*** *involves getting children to observe carefully, ask questions and employ methods to find answers.* (Male primary teacher).

*23: **teaching children about science** *is enjoyable and rewarding; also exciting. I find it one of the easiest subjects to provide differentiated work. I feel the lessons have to be balanced i.e. I must impart knowledge and facts but I must allow the children opportunity to participate actively by experimenting etc. I think it is important to teach children to write up experiments clearly and methodically.* (Female primary teacher).

In these written responses, as in the Likert-type questionnaire, the differences seem to reflect the differences in the perceived roles of primary class teachers and secondary science teachers. Primary teachers are encouraging the development of skills and processes, and secondary science teachers are encouraging the development of knowledge and understanding of the subject matter. Primary teachers feel that they should give the child autonomy to develop these skills, whereas more secondary teachers feel that pupils need direction. These findings support the views of Lee et al (1995) that at primary school the focus is on <u>learning</u>, and at secondary school it is on <u>subject knowledge</u>. It is also interesting to note the similarity with the results of research using the goal theory approach in the USA (Midgley, Anderman and Hicks, 1995); the elementary teachers were more concerned to encourage effort and the development of skills but the middle school teachers were more focused on achievement.

4.4.5 Teachers' written comments about the nature of science

Teachers' written completions of the phrase 'science is ...' fell into three broad groups: expressions of emotions about science, descriptions of scientific activity, and views about the nature of science (Table 4-27). Most of the responses were descriptive: there were some who simply described science teaching, but only a very few made any attempt to describe their views about the Nature of Science, although they had just been asked to think about that when responding to the questionnaire.

Table 4-27: Types of response about science by primary & secondary teachers

Views of science	**Primary**	**Secondary Science**
	n	**n**
Emotions	33	30
Descriptions	59	71
Nature of science	9	18
Total responses	101	119

The small number of responses dealing with the Nature of Science might indicate that the majority of these teachers had a very limited view of the Nature of Science, as suggested by the literature (Abell & Smith, 1994; Hayes & Johnstone, 1995). Twice as many secondary science teachers wrote specifically about the Nature of Science, but even here there were many who appeared to confuse the Nature of Science with science education.

These findings mirror those described and discussed on page 249, where it was suggested that primary teachers, might have difficulty developing a view of the Nature of Science; it seems possible that secondary science specialists may have the same difficulty. The literature dealing with secondary science teachers' view of the nature of science suggests that many secondary science specialists are unable to give consistent responses about the Nature of Science (Koulaidis & Ogborn, 1989). It seems likely that the majority of primary teachers and secondary science teachers may not have a clear idea of the Nature of Science.

The emotions expressed about science were grouped under four main headings: positive, negative, interesting and difficult (Table 4-28).

Table 4-28: Emotions about science expressed by teachers

Emotions	Primary	Secondary Science
	n	n
Negative	9	0
Interested	12	6
Positive	6	17
Difficult	14	0
Miscellaneous	4	7

Positive comments were made mainly by secondary science teachers, but there were also some positive comments from primary teachers, for example,

> *140: ***Science is*** *great it never ceases to amaze.* (Male primary teacher).
>
> *157: ***Science is*** *fascinating and absorbing.* (Female primary teacher).

However, generally the feelings expressed in this section of written responses indicated more negative than positive views about science among the primary teachers (Table 4-28).

> *173: ***Science is*** *complicated, challenging, frightening and necessary.* (Female primary teacher).
>
> *69: ***Science is*** *not my favourite subject!* (Female primary teacher).
>
> *161: ***Science is*** *often a mystery to me. I gave it up as quickly as I could* (Male primary teacher).

Fourteen primary teachers suggested that the difficulty of science led them to take a negative view.

> *125: ***Science is*** *quite often beyond my own comprehension, so at times I take a negative view especially physics.* (Female primary teacher).

As might be expected, since sciences were their chosen specialisms, the secondary scientists made no negative comments about science. Instead they made very positive comments such as, *8 ***Science is*** *excellent.* (Female secondary teacher).

*12 ***Science is*** *exciting.* (Male secondary teacher)

*13 **Science is** *interesting and enjoyable* (Male secondary teacher)

Analysis of the descriptions of science revealed the same division in views between primary and secondary teachers that has been observed in the questionnaire responses; secondary teachers referred more often to ‘understanding and knowledge’ and primary teachers to the ‘processes of science’ (Table 4-29).

Table 4-29: Descriptions of science given by teachers.

Descriptions	Primary	Secondary Science
	n	n
Understanding	31	41
Processes	22	13
Part of life	4	15
Teaching	6	2

Although both primary and secondary teachers described process views, primary teachers were more likely to give such descriptions.

*28, ***Science is*** *questioning, hypothesising and forming an opinion about all things living and non-living* (female primary teacher.)

*136 ***Science is*** *as much about process, if not more, as it is acquiring an understanding of the world around us.* (Male primary teacher.)

*79 ***Science is*** *the discovery through practical investigation of the nature of the world.* (Male secondary teacher.)

* 54 ***Science is*** *a process of forming opinions/conclusions from fair experimentation and close observation of the results.*
(Female secondary teacher.)

Few teachers expressed a view about the nature of science, but the majority of those who did were secondary science teachers. Their views might be classified using the categories developed in Section 3 of the questionnaire, and this would lead to the groups shown in Table 4-30. Clearly their views covered a wide spectrum, and there are no clear differences between the sorts of views expressed by primary and secondary teachers.

Table 4-30: Views about the nature of science expressed by teachers.

Nature of science	Primary	Secondary Science
	n	n
Inductive	1	0
Deductive	0	4
Process	1	3
Realist	3	4
Instrumentalist	2	0
Relativist	2	4
Contextual	2	2
Decontextual	1	1

For example, both primary and secondary teachers expressed relativist views:

> *65 ***Science is*** *carried out in a society which will affect the nature of the science that is carried out. Western science dominates other forms of knowledge - these are then ignored. The danger is people believe science is objective and a superior form of knowledge.* (Female primary teacher)

> *31 ***Science is*** *a body of knowledge, obtained through a unique method of inquiry, which is dynamic and involving. It is an interpretation, rather than a reflection of reality, although it is based upon observation and experimentation of events and the behaviour of the material world.* (Male secondary teacher)

Both primary and secondary teachers also expressed contextualist views:

> * 90 **Science is** *as much influenced by society, politics and moral value judgements as any other area of knowledge.* (Female primary teacher)

> *123 ***Science is*** *advanced by subjecting ideas to experimental verification or preferably by experimental nullifications; it strives to eliminate the views and influences of scientists but often fails in this aspect and sometimes uses intuitive leaps as a source of inspiration.* (Male secondary teacher)

In summary, few teachers at primary or secondary school could be regarded as expressing direct views about the Nature of Science. Where such views were articulated they were more likely to be from secondary science teachers, but it was not possible to detect any patterns in these views.

4.4.6 Relationships within data from the teachers' questionnaire

The data in section one is mainly categorical, so Chi squared calculations were used to investigate relationships between these data sets. The data in sections two and three are regarded as rank-order ordinal data and so relationships between these are investigated using Spearman correlation coefficients.

Finally combinations of categorical (more than two categories) and rank-order data are investigated using Spearman's correlation coefficients, where there are only two categories then Mann Whitney tests are used.

4.4.6.1 Relationships from section one of the questionnaire

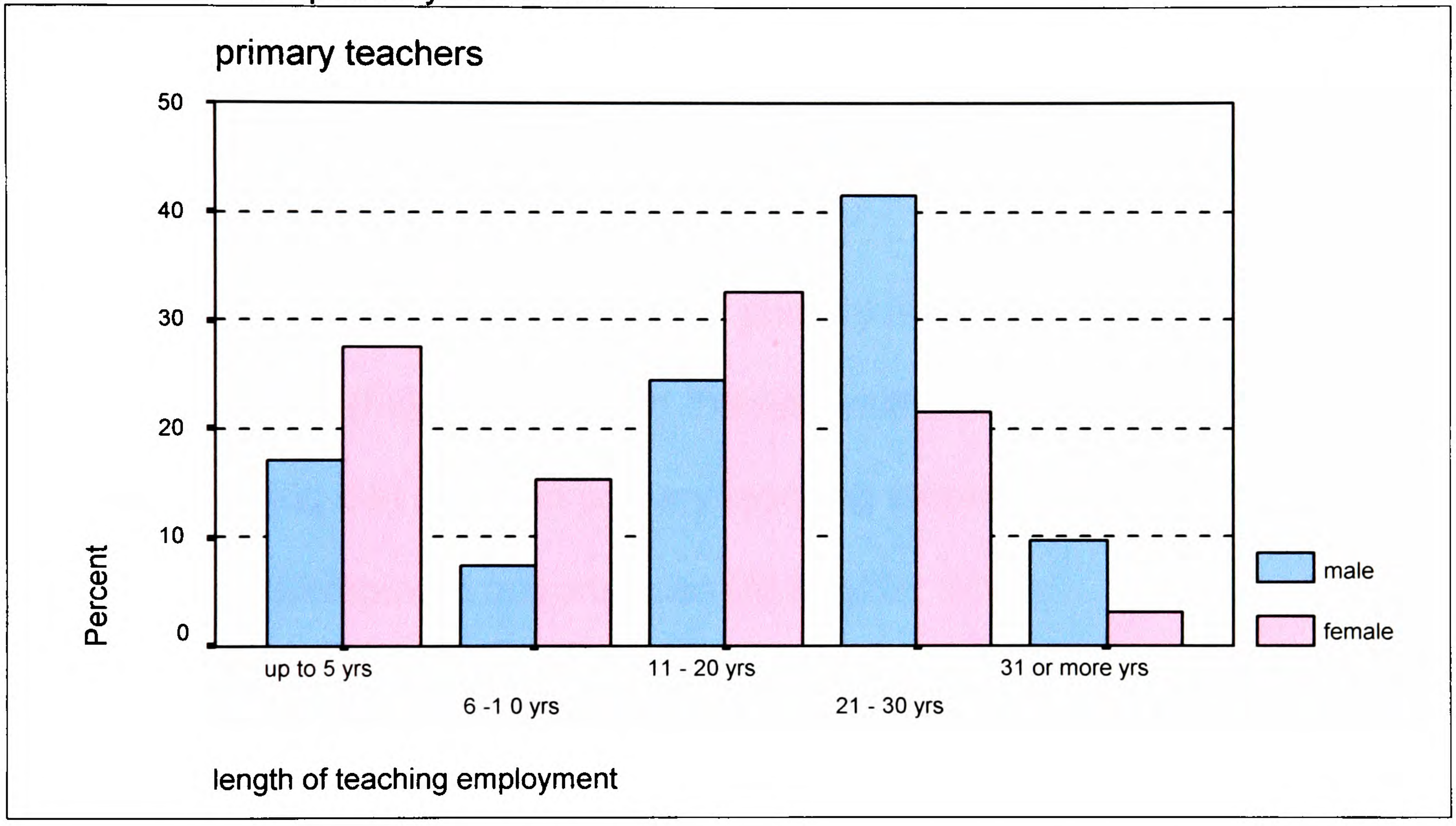
Relationships between these data sets were investigated using Chi squared calculations, and the results obtained are shown in Table 4-31; some statistically significant relationships were observed. The Chi squared tests suggest that there is a significant difference for length of teaching experience between men and women in both teaching sectors. Women are more likely to have been in teaching for shorter lengths of time than men.

Table 4-31: Significant relationships between teacher biographical variables

Case processing summary	**Primary**		**Secondary**	
	Pearson Chi-Square	**Asymp. Sig. (2-sided)**	**Pearson Chi-Square**	**Asymp. Sig. (2-sided)**
Length teaching employment * gender	10.19	0.037	23.34	0.000
Science INSET * gender	4.26	0.039	0.06	0.798
Length of non-teaching employment * gender	5.55	0.236	0.97	0.915
Non-teaching employment * gender	4.01	0.260	12.19	0.007
Highest qualification * gender	5.35	0.374	9.93	0.077
Subject of highest science qualification * gender	3.57	0.613	13.01	0.023
Science qualification * gender	2.57	0.766	0.166	0.997

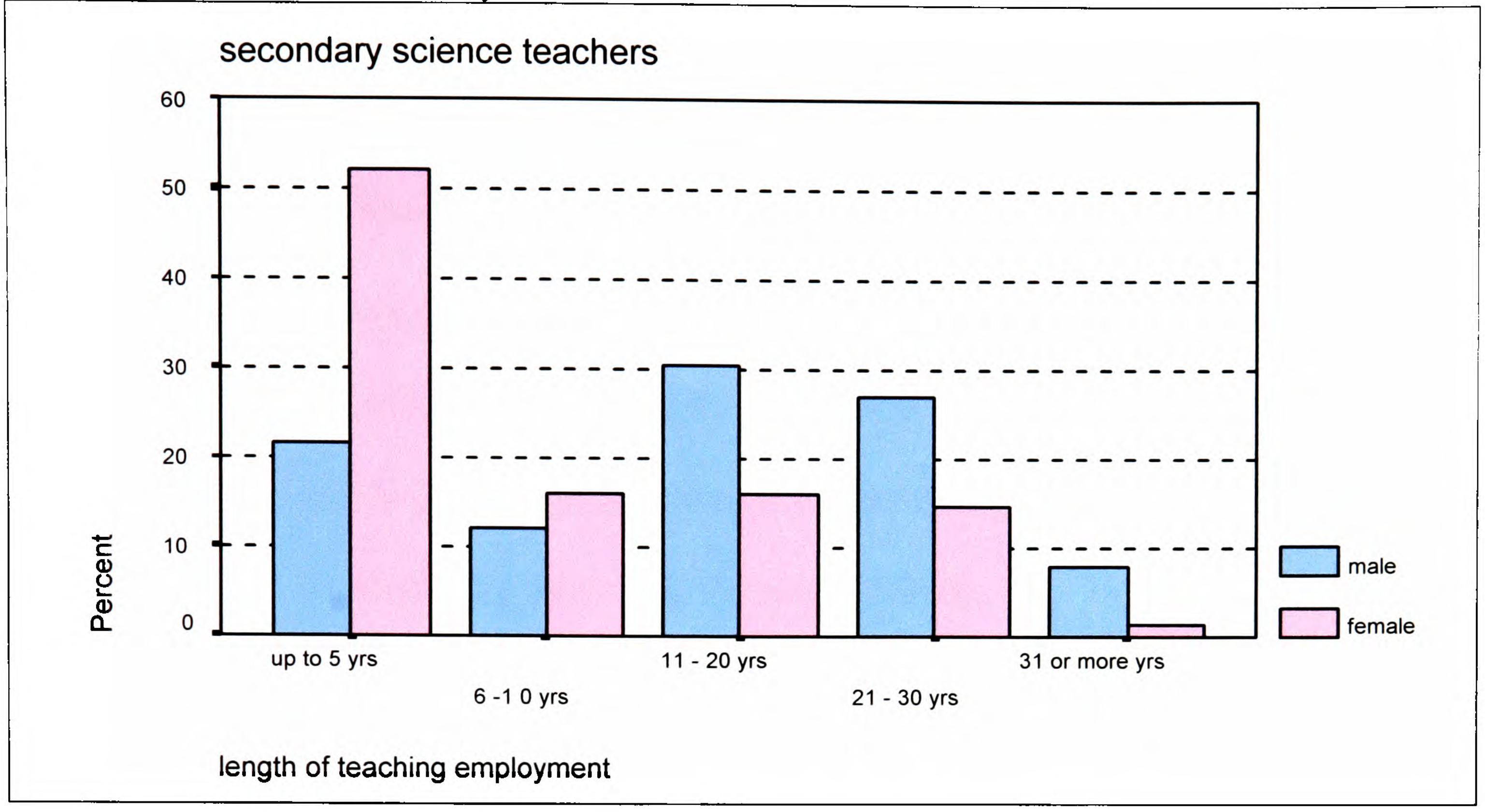
In the primary sector the results indicate that more men have at least 21 years teaching experience, whereas more women have less than 20 years experience (Figure 4-20, below). This is supported by observations by Howson (1998), which indicate an aging population of male primary teachers who are not being replaced by other males, suggesting that primary teaching is becoming more feminised.

Figure 4-20: Relationship between length of teaching employment and gender for primary teachers.



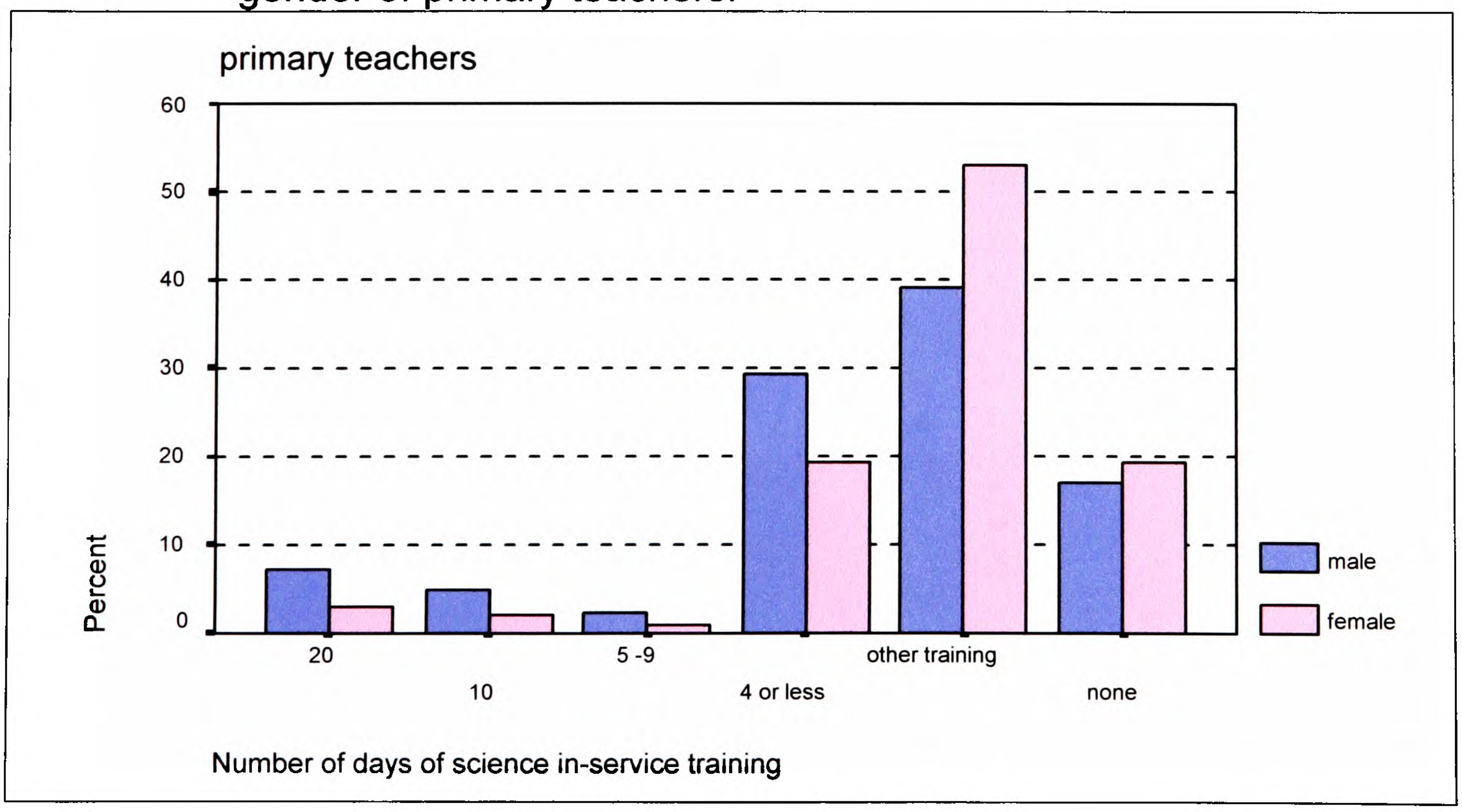
It is interesting to observe a similar phenomenon in secondary science teaching (Figure 4-21); again statistics indicate less males being recruited into secondary teaching generally (DFEE, 1999), and this phenomenon may be reflected in the results obtained here.

Figure 4-21: Relationship between length of teaching employment and gender for secondary teachers.



The chi squared tests suggest that male primary teachers have more opportunities for science INSET (Figure 4-22), and this observation would certainly fit with other research showing that males in primary teaching receive more of the higher status professional development opportunities (Al-Khalifa, 1989).

Figure 4-22: Relationship between science INSET over the last 5 years and gender of primary teachers.



Lastly these chi-squared tests suggest that male secondary science teachers may have rather different backgrounds from their female colleagues. Male teachers are more likely to have had previous experience in a science-based non-teaching occupation, and to have studies a physical science subject (Figures 4-23 and 4-24). Such data is supported by statistics indicating a greater take up of physical science subjects at school and in HE by boys (see for example, Colley et al, 1994; Stables, 1996), and a greater proportion of males being employed in science-based jobs (for example, Lightbody & Durndell, 1998).

Figure 4-23: Proportion of male and female secondary science teachers with employment experience outside of teaching.

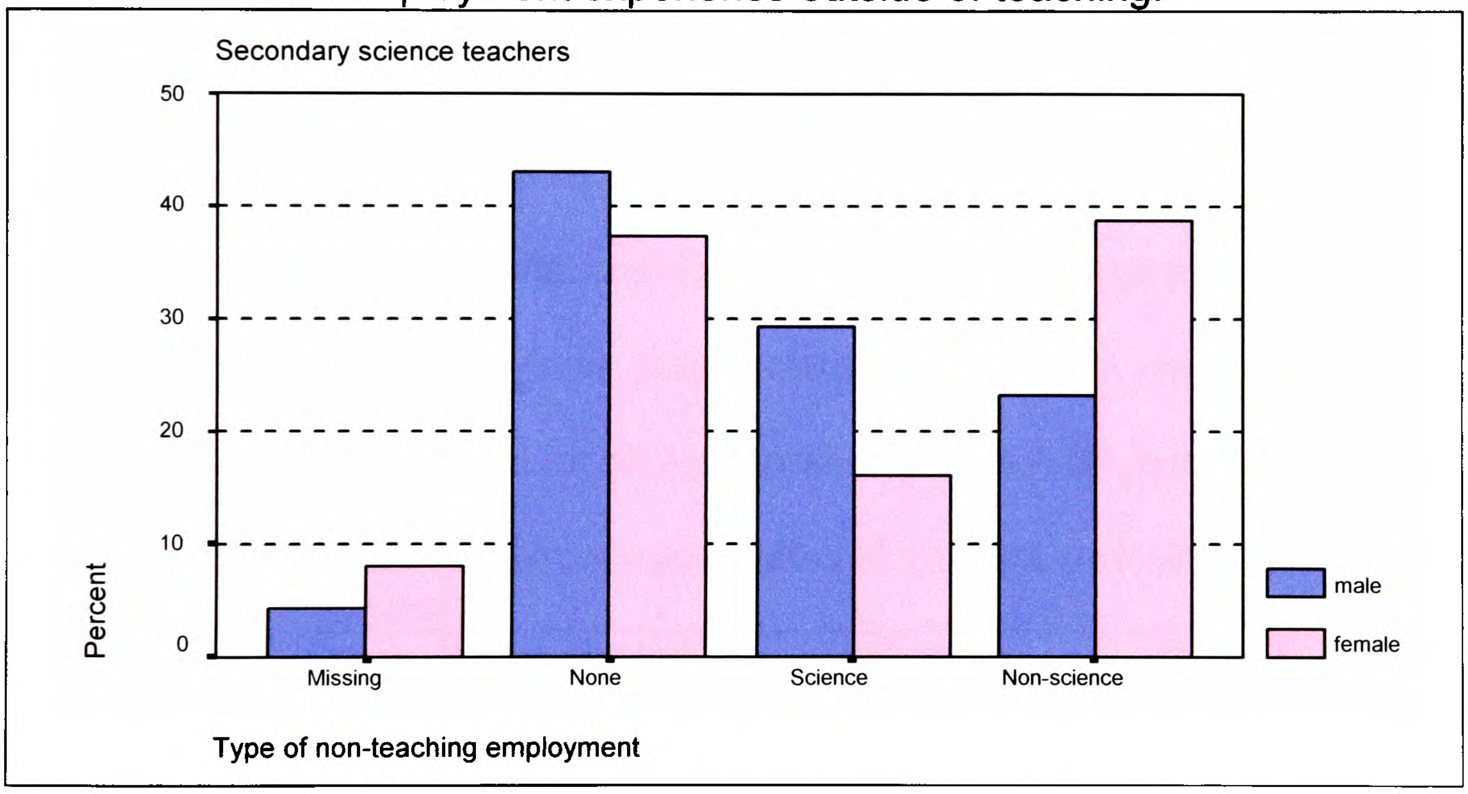
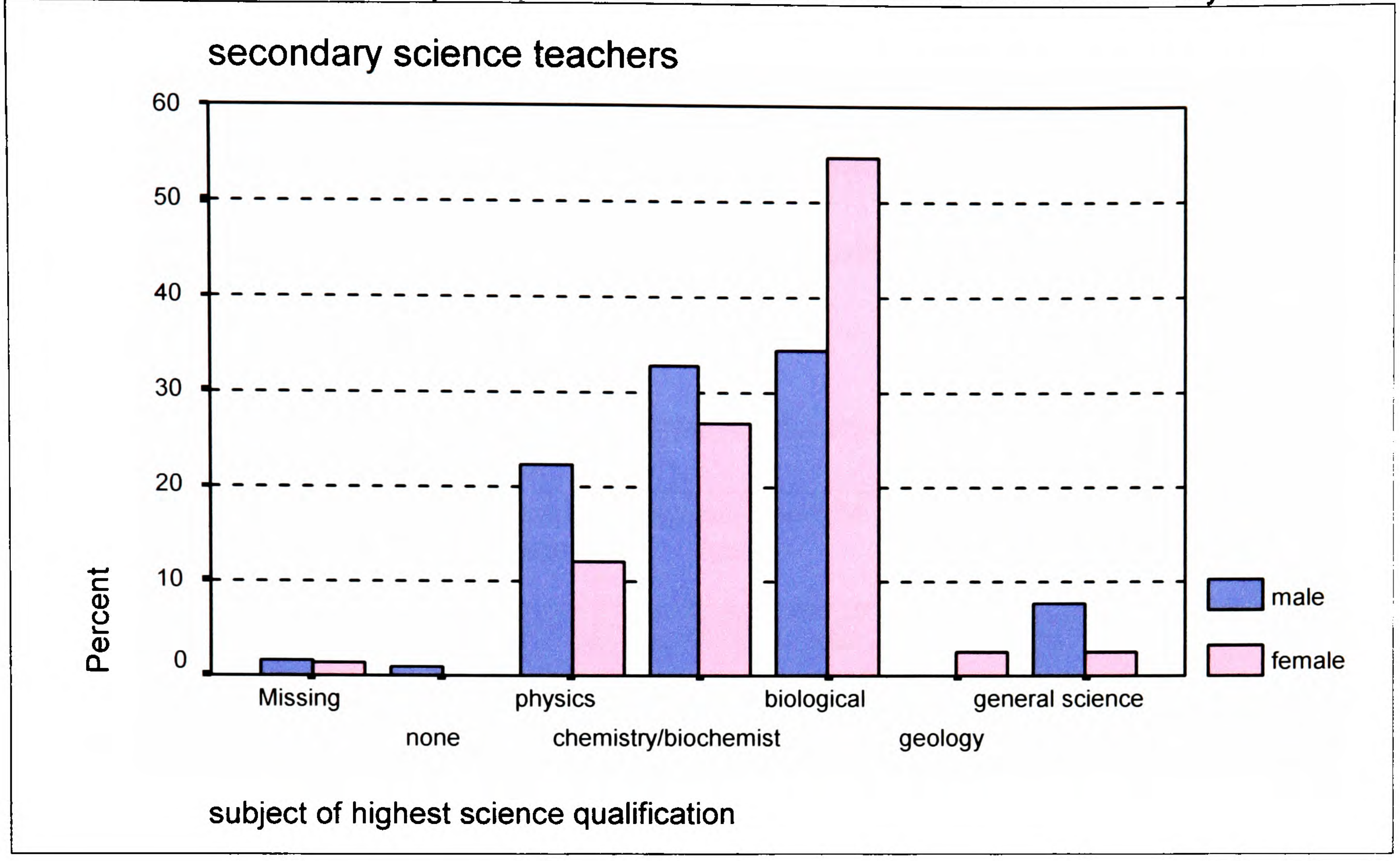


Figure 4-24: Science subject qualifications for male & female secondary teachers



4.4.6.2 RELATIONSHIPS FROM SECTIONS TWO AND THREE OF THE QUESTIONNAIRE

To identify any significant relationships between teachers stated approaches to science teaching and their views about science Spearman's rank order correlations were calculated for all the teachers (Table 4-32, below).

Table 4-32: Correlation between approaches to science and views of science (all teachers).

Spearman's rank-order correlations	Process-content factor	Inductive-deductive factor	Contextualist-decontextualist factor
Knowledge factor	0.084	-0.170**	-0.052
Science and society factor	-0.040	-0.054	0.059
Child-centred factor	-0.205**	0.082	0.032
Motivation factor	-0.027	-0.066	0.035

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

The results of these calculations suggest that there may be significant relationships between what teachers say they think is important in their science teaching, and their views about the Nature of Science. Teachers with a process view of science are likely to say they value a more child-centred approach, and teachers with a more inductive approach are likely to say they take a more knowledge based approach to teaching. However, since there were also significant differences between the teachers in the two sectors the significances must be checked by calculating Spearman rank order correlation coefficients for each sector of teaching (Table 4-33).

Table 4-33: Correlation between approaches to science and views of science (by teaching sector).

Spearman's rank-order correlations	Main area of teaching	Process-content factor	Inductive-deductive factor	Contextualist-decontextualist factor
Knowledge factor	primary	-.023	-.341**	-.045
Knowledge factor	secondary	.071	-.155*	-.123
Science and society factor	primary	-.128	-.040	.079
Science and society factor	secondary	.011	-.084	.044
Child-centred factor	primary	-.259**	.047	.056
Child-centred factor	secondary	-.137#	.132	.064
Motivation factor	primary	-.052	-.077	.055
Motivation factor	secondary	.014	-.038	.043

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).
# Correlation is significant at the .06 level (2-tailed).

The significant relationships are similar for primary and secondary teachers: there is a significant association between the knowledge and the inductive-deductive factors for both teaching sectors, and between the child-centred and process-content factor for primary teachers. However, this latter relationship is only just outside the significance level for secondary teachers.

The general trends shown in Figures 4-25 and 4-26 suggest that teachers in both sectors, with a more inductive view of science, are likely to regard items in the knowledge factor as more important than are teachers who take a more deductive view.[1]

[1] The items included in the knowledge factor were:

Ensuring sound knowledge of theoretical concepts and principles
Providing experimental results and information which explain the natural world
Passing on scientific knowledge
Illustrating that scientific knowledge is objective and true
Supplementing the curriculum with more detailed information

Figure 4-25: Relationship between the knowledge factor and the inductive-deductive factor for primary teachers

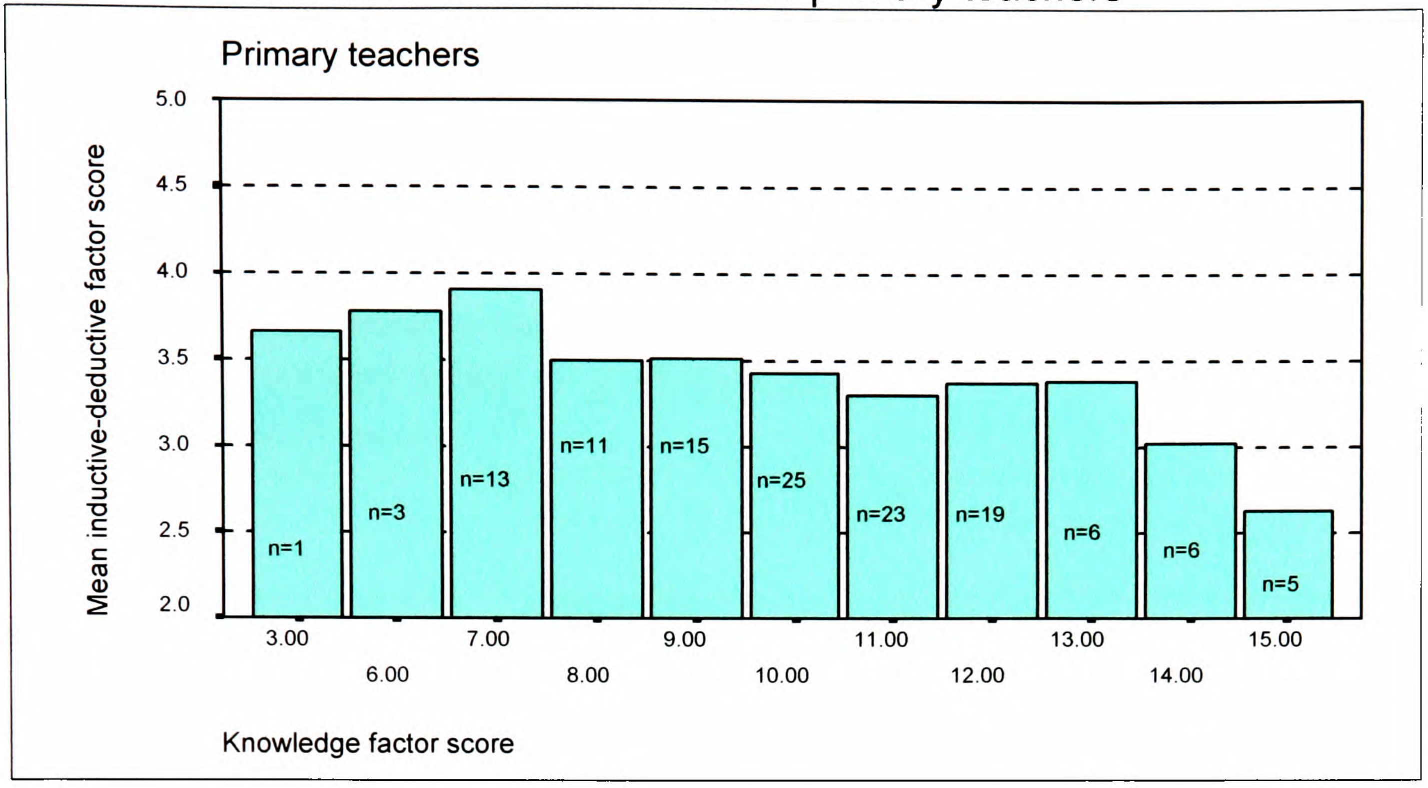
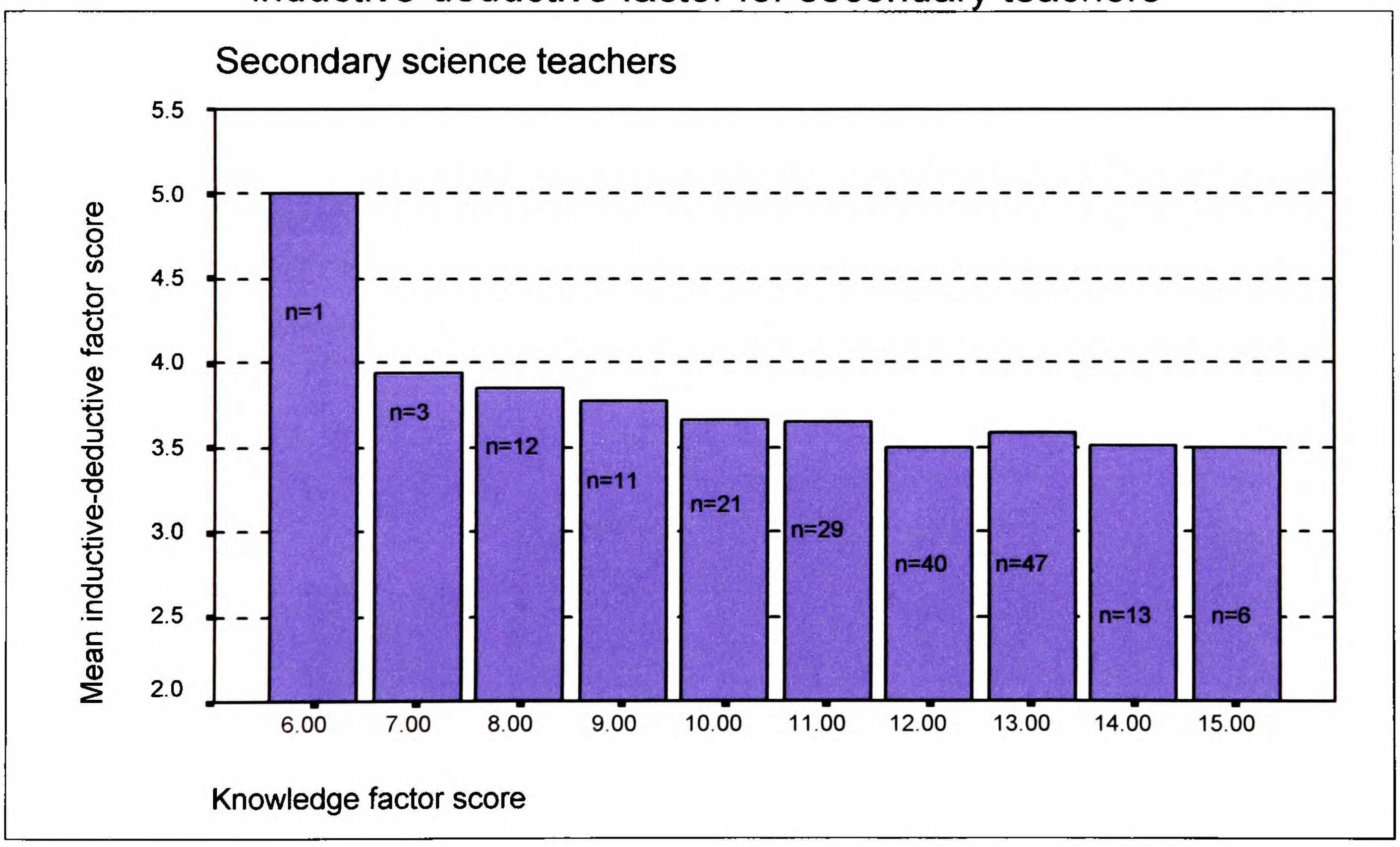


Figure 4-26: Relationship between the knowledge factor and the inductive-deductive factor for secondary teachers



A high score indicates that the teachers regards these as important in science teaching and a low score indicates that they are regarded as unimportant. The items included in the inductive-deductive factor were:

Scientists have no idea of the outcome of an experiment before they do it
New scientific knowledge is entirely the result of many new experiments and observations
Scientific theories are as much a product of imagination and intuition as inference from experimental results

Agreements with the first two and disagreement with the last item gives a low score and suggests an inductive view of science and vice versa.

The general trends shown in Figures 4-27 and 4-28 below suggest that teachers in both sectors with a more process view of science are likely to regard items in the child-centred factor as more important than are teachers who take a more content-based view.[1]

Figure 4-27: Relationship between the child-centred factor and the process-content factor for primary teachers

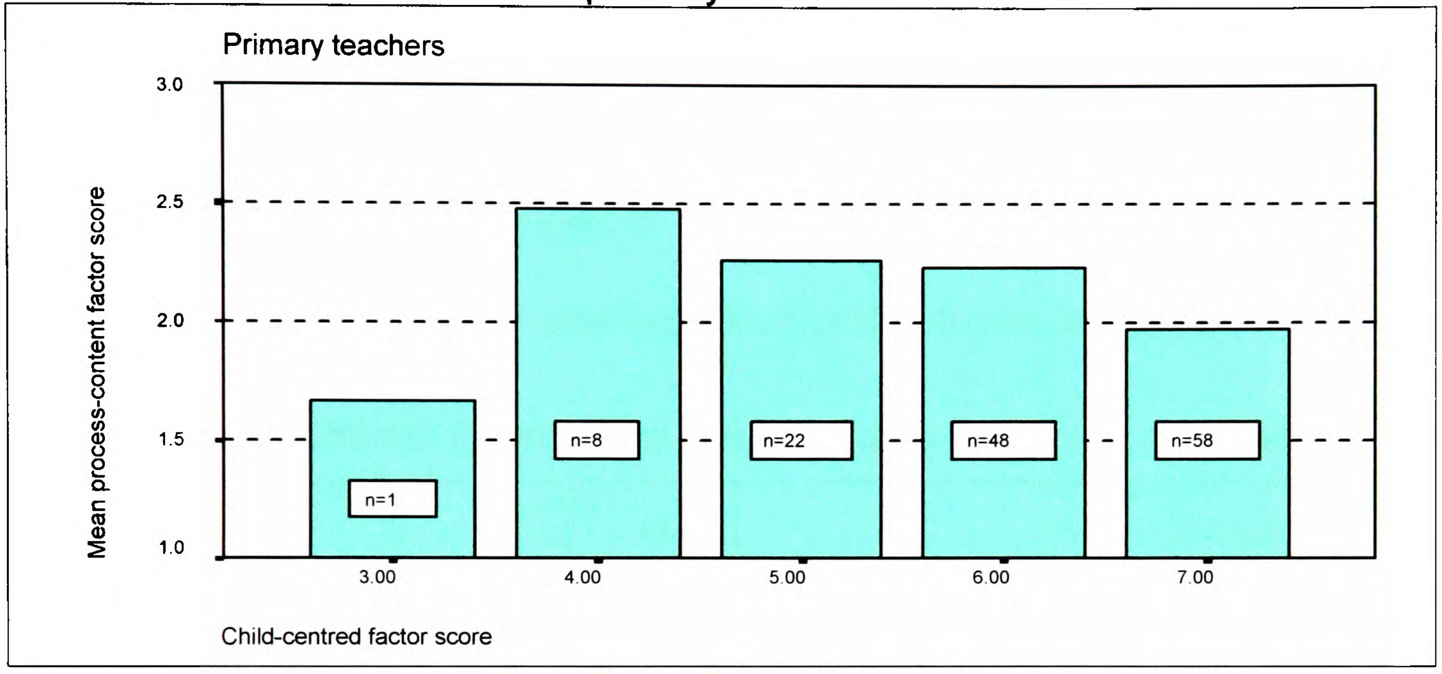
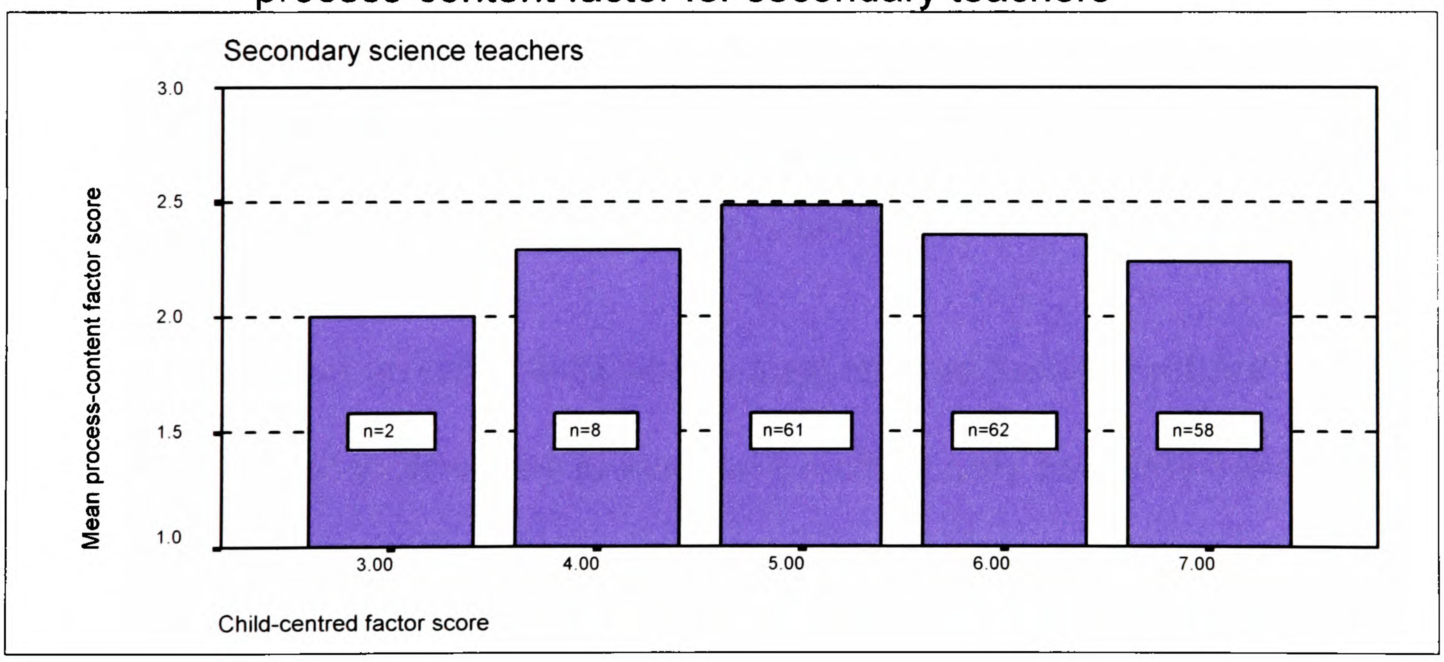


Figure 4-28: Relationship between the child-centred factor and the process-content factor for secondary teachers



[1] The items included in the child-centred factor were:

Providing opportunities for discussions of children's own scientific ideas
Helping children to construct their own explanatory models

A high score indicates that the teacher regards these as important in science teaching and a low score indicates that they are regarded as unimportant.The items included in the process-content factor were:

Science education should be more about the learning of scientific processes than the learning of scientific facts
The most valuable part of a scientific education is what remains after the facts have been forgotten
'Scientific method' is transferable from one scientific investigation to another

Agreements with these items gives a low score and suggests a process view of science and vice versa.

These associations suggest that there may be a link between the way teachers' view science and how they feel that they should teach it in the classroom. However, it must be remembered that the 'Views of science' factors had very low reliabilities and so the above links may not be important.

4.4.6.3 RELATIONSHIPS BETWEEN ALL VARIABLES FROM THE TEACHERS' QUESTIONNAIRE

The relationships between sub-scales and the biographical data with more than two categories were investigated using Spearman's correlation coefficients; the results of these are summarised in Table 4-34. Only teachers with scores on all items included in the sub-scales were included in these analyses.

Table 4-34: Correlations between biographical data & sub-scale scores (all teachers)

Spearman's rank-order correlations	Science and society factor	Child centred - factor	Motivation factor	Knowledge factor	Process-content factor	Inductive-deductive factor	Contextualist-decontextualist factor
Post of responsibility	0.136	0.000	-0.074	0.110	-0.004	0.054	0.031
In-service training	-0.006	0.136*	0.050	-0.148*	-0.091	0.005	-0.059
Highest qualification	0.016	0.028	-0.008	0.013	-0.074	-0.175**	-0.069
Subject of highest science qualification	0.017	0.025	0.038	-0.039	-0.034	-0.048	-0.105
Highest science qualification	0.008	-0.108	-0.079	0.213**	0.131*	0.188**	0.137*
Non teaching employment	-0.090	-0.006	-0.014	-0.082	-0.101	-0.054	-0.060
Length of non-teaching employment	-0.029	-0.008	-0.008	-0.038	-0.058	-0.017	0.062

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

The results shown in Table 4-34 above suggest that these teachers' views about science and their approaches to science teaching may be related to their training (INSET, science qualifications, and general qualifications). However, the teachers in the two sectors held very different science qualifications (page 242), and further analysis including science qualifications and teaching sector indicates that it may be the teaching sector and *not* the science qualifications that are significantly related to views and approaches (see Appendix, Tables 5-18 and 5-19). Thus, once again the Spearman's correlation coefficients are calculated for each sector separately (Tables 4-35 and 4-36, below).

Table 4-35: Correlations between biographical data & sub-scale scores (primary teachers

Spearman's rank-order correlations	Knowledge factor	Science and society factor	Child centred - factor	Motivation factor	Process-content factor	Inductive-deductive factor	Contextualist-decontextualist factor
Length teaching employment	.068	-.060	-.184*	-.036	.135	-.167	-.198*
Post of responsibility	-.132	.146	.077	-.098	-.150	-.065	-.099
In-service training	-.079	.051	-.009	-.004	-.011	.195*	-.018
Highest qualification	186*	-.030	-.007	.003	-.094	.140	-.082
Subject of highest science qualification	.148	-.034	-.006	-.011	.044	.036	-.028
Highest science qualification	-.004	.045	100	-.015	-.034	.061	.080
Non teaching employment	-.163	.082	.014	-.099	-.072	.004	.040
Length of non-teaching employment	-.062	174	.094	-.136	.038	.001	.079

Table 4-36: Correlations between biographical data & sub-scale scores (secondary teachers)

Spearman's rank-order correlations	Knowledge factor	Science and society factor	Child centred - factor	Motivation factor	Process-content factor	Inductive-deductive factor	Contextualist-decontextualist factor
Length teaching employment	.170*	.101	-.040	-.061	-.035	-.022	.143*
Post of responsibility	.134	.109	-.015	-.061	.015	.073	.078
In-service training	-.058	.016	.166*	-.008	-.084	-.045	-.028
Highest qualification	-.012	.124	-.045	-.093	.008	-.135	-.003
Subject of highest science qualification	-.017	.075	-.092	.023	.014	-.061	-.120
Highest science qualification	-.031	-.100	-.030	.037	-.017	.090	.027
Non teaching employment	.016	-.138	-.056	.000	-.066	-.035	-.067
Length of non-teaching employment	-.054	-.115	-.064	.044	-.098	-.009	.059

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

The results of these calculations indicate that for both sectors the length of teaching employment and INSET may be important. In both sectors the extent of the contextualist or decontextualist view expressed is significantly linked with the length of teaching employment. Primary teachers who have been teaching for a shorter length of time appear to take a more contextualist view of science, and secondary teachers who have been teaching for a shorter length of time take a more decontextualist view of science. When the two bar charts illustrating these changes are examined (Figures 4-29 and 4-30, below) it is apparent that there is a significant difference in views for teachers from the two sectors with more than 10 years teaching experience.

Figure 4-29: Relationship between length of teaching employment and the contextualist-decontextualist score of primary teachers.

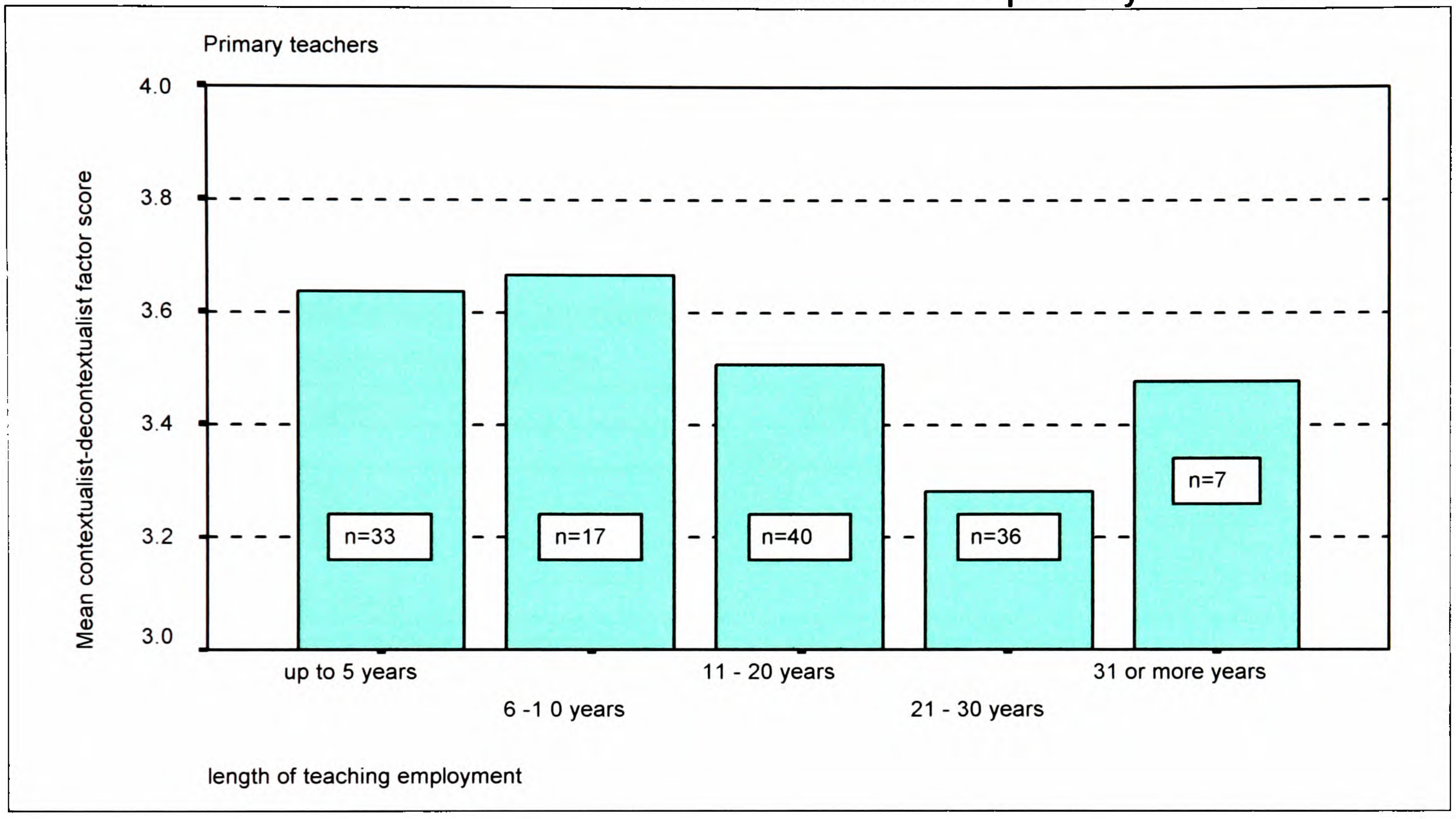
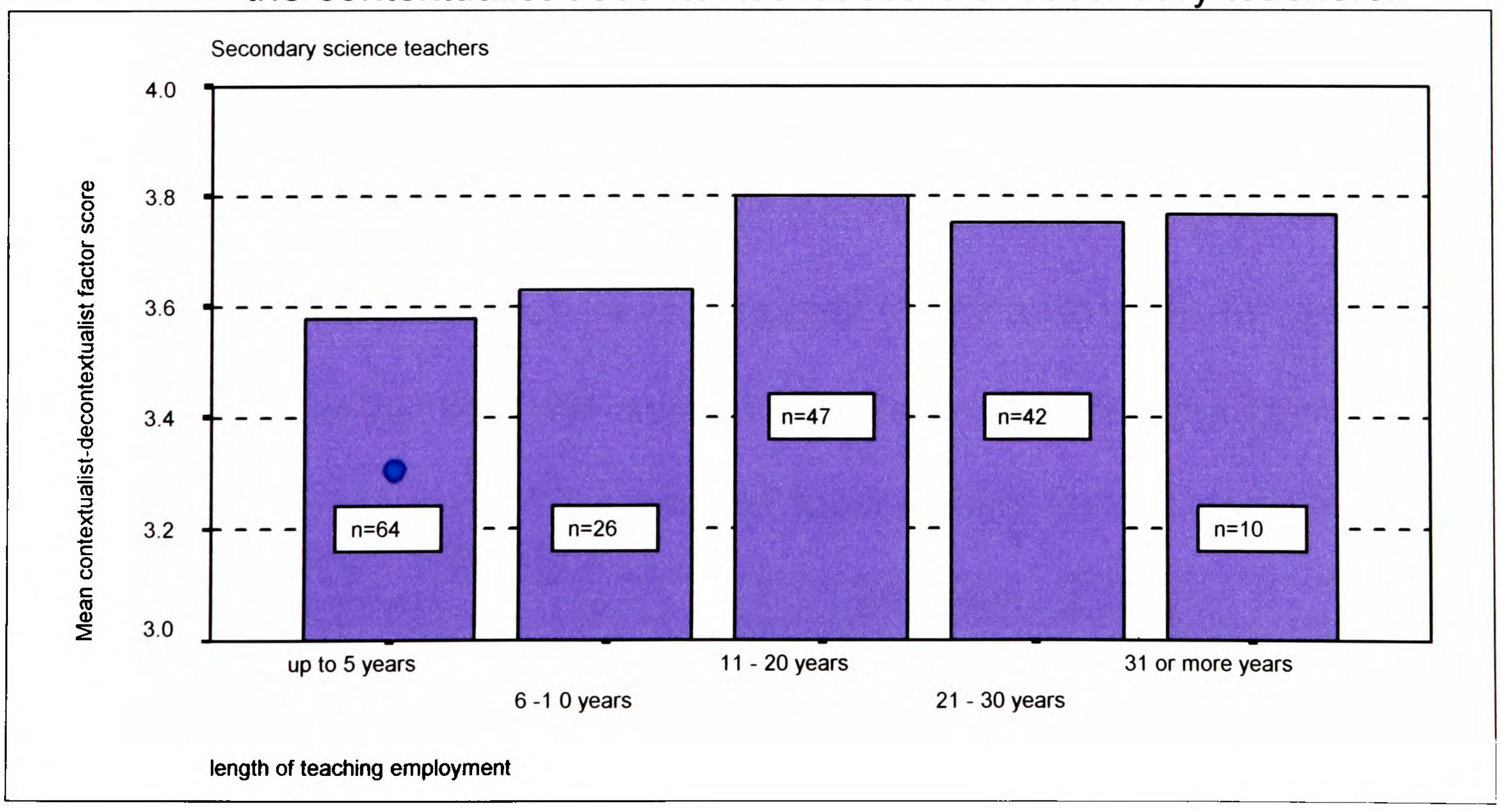


Figure 4-30: Relationship between length of teaching employment and the contextualist-decontextualist score of secondary teachers.



Primary teachers with more than 10 years experience are likely to hold relatively decontextualist views whereas secondary teachers with comparable lengths of teaching experience are likely to hold fairly contextualist views. However, teachers in both sectors, with up to 10 years experience, have similar scores on the contextualist-decontextualist scale. A Mann Whitney test indicates that there is a significant difference in views for secondary teachers with more or less than 10 years teaching experience ($p<0.05$) but that for primary teachers the difference is just outside statistically significance (Table 4-37).

Table 4-37: Significance of CD scores for teachers with more or less than 10 years experience

Mann Whitney tests	Main area of teaching	
	Primary	Secondary science
Mann-Whitney U	1667.500	3664.000
Wilcoxon W	5153.500	7759.000
Z	-1.919	-2.129
Asymp. Sig. (2-tailed)	.055	.033

N.B. Grouping variable: teaching experience up to 10 years/more than 10 years

Perhaps the difference in views observed is related to the introduction of National Curriculum Science, introduced approximately 10 years before these teachers completed this questionnaire. However, when the Mann Whitney tests is applied with the grouping variable more or less than 20 years experience the difference for primary teachers is statistically significant, but that for secondary teachers is not (Table 4-38). Thus, the statistics indicate that there may be a significant difference in views among primary teachers with more or less than 20 years experience but among secondary teachers with more or less than 10 years experience.

Table 4-38: Significance of CD scores for teachers with more or less than 20 years experience

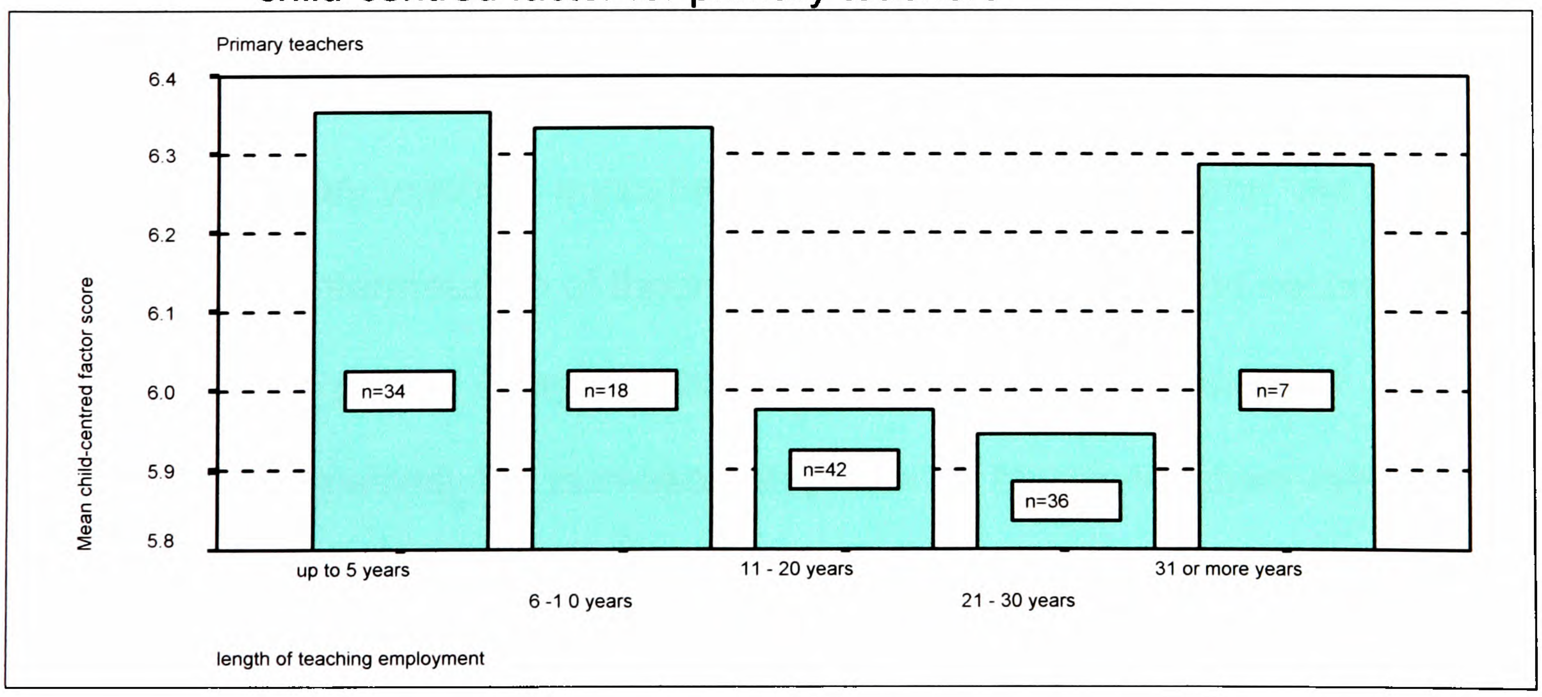
Mann Whitney tests	Main area of teaching	
	Primary	secondary science
Mann-Whitney U	1441.0000	3223.500
Wilcoxon W	2387.000	12676.500
Z	-2.409	-1.019
Asymp. Sig. (2-tailed)	0.016	0.308

N.B. Grouping variable: teaching experience up to 20 years/more than 20 years

These statistics suggest that the teachers' views may be related in part to their sex, since the increased recruitment of female teachers and the decline in the recruitment of male teachers has altered the gender balance in primary teaching the last 20 years (page 266).

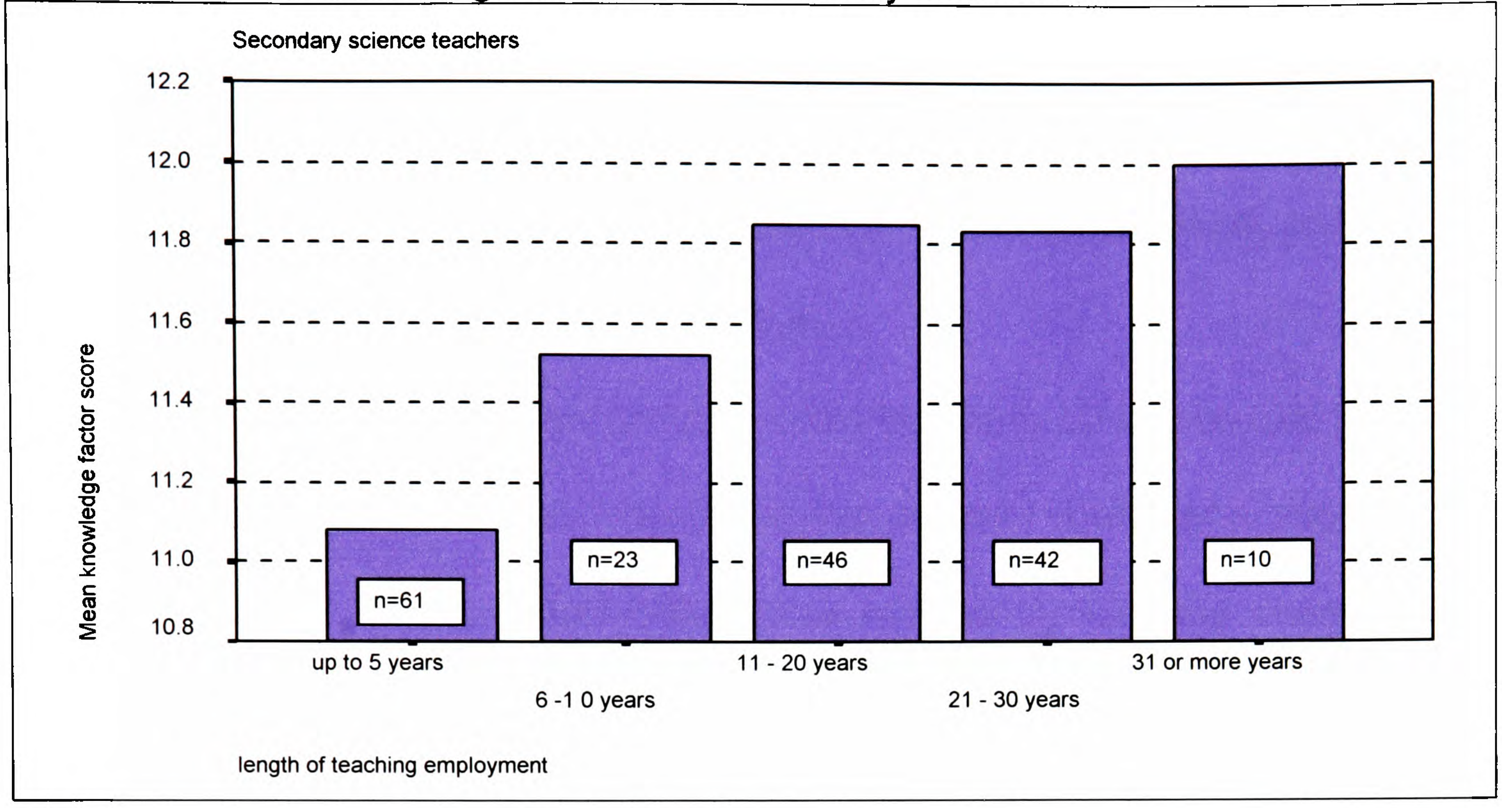
Teachers' approaches to science teaching also appear to be significantly related to the length of teaching experience; for each sector the related approach is the one that has already been shown to be particularly associated with that sector[1]. Primary teachers' with greater teaching experience were less likely to adopt a child-centred approach and secondary teachers with greater teaching experience were more likely to adopt a knowledge-based approach. Inspection of Figures 4-31 and 4-32, below, suggests that there may be two possible interpretations of the results: there may be associations between teaching experience and teaching approaches, as suggested by the Spearman correlation coefficients, or there may be differences between teachers with more or less than 10 years teaching experience.

Figure 4-31: Relationship between length of teaching employment and score on child-centred factor for primary teachers



[1] On p.248 it was shown that primary teachers were more likely to have a child-centred approach and secondary teachers were more likely to have a knowledge-based approach.

Figure 4-32: Relationship between length of teaching employment and score on knowledge factor for secondary teachers

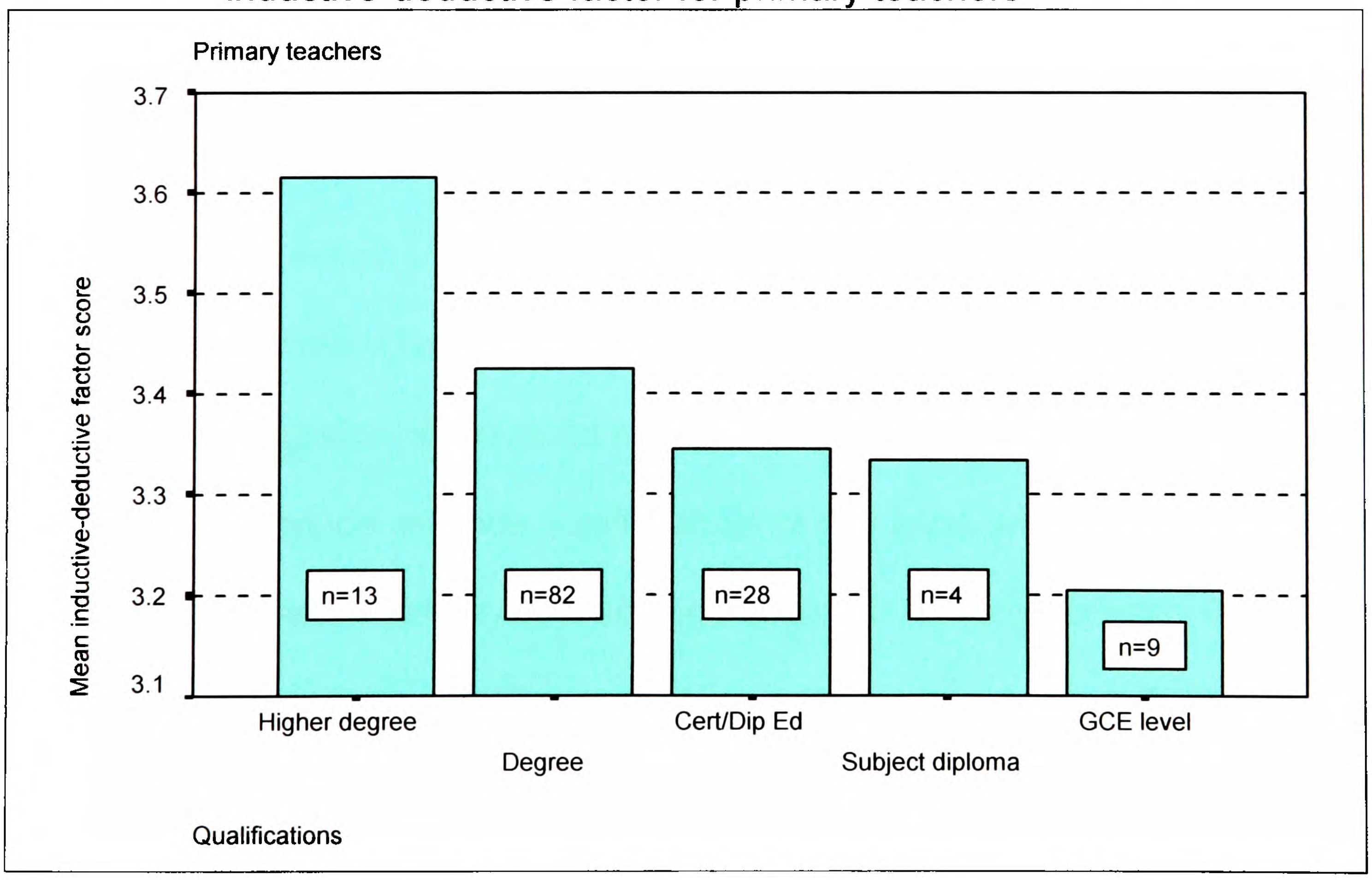


The first interpretation of teaching approach being related to teaching experience, suggests that teaching is a learning experience: primary teachers using a less child-centred approach with greater experience, and secondary teachers using a more knowledge-based approach with time. The alternative interpretation of a difference between teachers with more or less than 10 years teaching experience, suggests that the introduction of the National Curriculum, changes in teacher training and the changed gender balance of recruits may be related to teachers' approach to teaching science. Perhaps as a result of the Science National Curriculum primary teachers might be being guided towards greater use of discussion and interpretation of theories and ideas in science, and secondary teachers may be guided away from an emphasis on the transmission of knowledge. Alternatively the increased proportion of female teachers may regard science and science teaching in a different way from their male colleagues.

It is difficult to decide which interpretation is the more likely. The trend shown in Figure 4-31 is distorted by the small group of only 7 teachers with more than 31 years in teaching, and so a relationship between experience and approach seems likely. However, gender differences cannot be ruled out since there are some significant differences in approach and views that appear to be gender related (page 280), although these gender differences do not relate directly to those under discussion, nevertheless there may be links.

INSET appears to be linked to the primary teachers' ID scores and to the secondary teachers' f3 scores. Spearman's correlation coefficients suggest that primary teachers' inductive-deductive scores may be significantly related with their general level of qualifications (Figure 4-33). Bearing in mind the limitations of the inductive-deductive factor, this association could simply indicate that teachers with higher qualifications are more likely to use deductive procedures in general, and that their personal experiences have been related to their views about science.

Figure 4-33: Relationship between highest qualification and score on inductive-deductive factor for primary teachers



Gender differences were investigated by simple non-parametric tests, and significant differences between male and female teachers were found on two sub-scales: f4 (KW $p<0.001$) and ID (KW $p<0.05$). Female teachers were more inclined to use motivating techniques in their teaching and also were more likely to hold inductivist views of science. Since there are far more female primary teachers it could be thought that these relationships arise from teaching in a particular sector, rather than being associated with one particular sex. However, statistical tests (UNIANOVA – see Appendix 5) indicate that for these variables the teaching sector is not significant.

Although the results of analysis have suggested that there are significant relationships within this data from the teachers, it must be remembered that the 'views of science' factors could not be regarded as particularly reliable or valid. So it is possible that the above relationships, which involve that factor, have no importance at all, particularly where the significance level was low.

4.4.7 Summary

In general, the secondary teachers had higher qualifications, and, as might be expected, the primary school teachers were less well qualified in the *sciences* than the comparison group of *specialist* secondary *science* teachers. Very few primary teachers had physical science qualifications at any level, whereas almost half the secondary teachers held physical science degrees. Although primary teachers, in general, lacked science qualifications, they received little science INSET in comparison with their secondary colleagues, and many had received no science training in the previous 5 years, either.

The majority of teachers at primary school felt that the transmission of scientific knowledge was not important, but most secondary school teachers regarded it as very important. Teachers in the primary sector were more inclined to take a child-centred approach than were teachers at secondary school. The secondary teachers were likely to hold more de-contextualist views about science than primary teachers. Secondary teachers were also likely to hold more deductivist and more content oriented views about science than primary teachers.

The feelings expressed in the written comments indicated that many primary teachers had rather negative views of science. Some expressed a lack of interest in science and others talked about their lack of knowledge and the difficulty of science.

Many teachers from both sectors thought that teaching science should involve understanding and experimental work, but different purposes seemed to lie behind these views. Primary teachers seemed to be encouraging the development of skills and processes and secondary science teachers seemed to encourage the development of knowledge and understanding of the subject matter. Primary teachers felt that they should give the child autonomy to develop these skills whereas more secondary teachers felt that pupils needed direction.

The small number of written responses dealing with the nature of science and the large number of missing responses to the Likert-type items on views about science suggests that many teachers do not have any definite views about the nature of science. The differences in the numbers of primary and secondary teachers who responded to such items suggests that primary teachers are much less likely than secondary science teachers to have a view of the nature of science.

The links observed between approaches to science teaching and views about the nature of science, for both primary and secondary teachers, indicates that teachers holding a particular view of the nature of science may regard a particular approach to classroom teaching as more or less important.

There are indications that the length of teaching experience may affect the teachers' stated approaches to teaching science and views about science, and that this may be connected with teachers' experience in the classroom, their level of INSET, the introduction of the National Curriculum in science, and with different outlooks of male and female teachers. However, there does not appear to be a close link between such views and the level of science education received.

CHAPTER 5. INFLUENCES ON CHILDREN'S ATTITUDES

5.1 Introduction

The previous chapter described the attitudes of children in years 6 and 7, but did not examine the influences of school or teacher variables on them. Since it is likely that children's attitudes to science lessons would be affected by many variables, it is necessary to control for the effects of such variables when investigating possible influential factors. For the present data, regression analyses have been used to do this, since many variables are involved (Bryman & Cramer, 1994), and the statistical models described in Chapter 3 have determined the sequence of each analysis. As explained in Appendix 2, regression analysis can shed light on the relative importance of the different independent variables; variables with no statistical significance are eliminated. The importance of the variables remaining is related to the amount of the variance that they explain (the R^2 value), and to the size of the unstandardised coefficient B; the larger these values, the more important the variable is likely to be[1]. In this chapter the results of these regression analyses are reported, showing the value of R^2 and B for each of the significant variables. The importance of these variables to children's attitudes to school and to science in years 6 and 7 is then discussed.

The results of the regression analyses for data from years 6 and 7 with the dependent variables concerning 'attitudes to science' (i.e. enjoyment of science, the difficulty of science and the difficulty of science writing) are shown in Tables 5-2 to 5-7, below; the full results of these regression analyses are given in Appendix 5.

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[1] However, the significance levels for each variable must also be taken into account, and these are detailed in Appendix 5

Table 5-1: Significant variables for enjoyment of science in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.20
Child	Gender	.011	0.011	-.24
School	Year 6 roll	.017	0.006	.00
Teacher	Length of non-teaching employment	.026	0.009	.04
	Score on knowledge factor	.033	0.007	-.03
Classroom activities	Collaborative activity	.042	0.009	.02
Attitudes to school	Enjoyment of school	.145	0.103	.28
	Enjoyment of schoolwork	.153	0.008	.11

Table 5-2: Significant variables for enjoyment of science in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.48
School	CASE	.023	0.0231	-.45
	Timetabled time available for liaison	.038	0.0153	-.15
	SALTERS	.049	0.0106	-.20
Teachers	F3	.067	0.0181	-.11
	F2	.081	0.0137	-.10
	Length of teaching employment	.101	0.0198	-.09
Classroom activities	Collaborative	.138	0.0375	.06
	Standardised	.148	0.0097	-.03
	Teacher directed	.155	0.0069	-.03
School attitudes	Enjoyment of school	.294	0.1394	.29
	Enjoyment of schoolwork	.307	0.0133	.16

Table 5-3: Significant variables for difficulty of science in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 4.43
Teachers	Length of non-teaching employment	.006	0.0055	-.05
	Length of teaching employment	.010	0.0042	-.04
Classroom activities	Teacher directed	.014	0.0046	.03
School attitudes	Enjoyment of school	.118	0.1034	-.38

Table 5-4: Significant variables for difficulty of science in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 4.72
School	CASE	.016	0.0163	.34
	One or more A-G grades %	.030	0.0142	-.01
	Selective school	.038	0.0079	-.20
Teachers	F3	.045	0.0066	.08
Classroom activities	Standardised	.059	0.0139	.06
	Collaborative	.066	0.0071	-.03
	Teacher directed	.075	0.0094	.04
School attitudes	Enjoyment of school	.217	0.1417	-.43

Table 5-5: Significant variables for difficulty of science writing in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 4.78
Child	Gender	.020	0.0203	-.14
School	Year 6 roll	.025	0.0051	.00
School attitudes	Enjoyment of school	.118	0.0924	-.31
	Enjoyment of schoolwork	.127	0.0095	-.14

Table 5-6: Significant variables for difficulty of science writing in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant =4.985
Child	Gender	.018	0.0176	-.136
School	CASE	.028	0.0100	.212
School attitudes	Enjoyment of school	.145	0.1172	-.310
	Enjoyment of schoolwork	.161	0.0165	-.211

Before looking at the details of these analyses, two general points about the results will be considered. First, in every analysis the most important variable contributing to the variation in attitude to science is found to be the enjoyment of school. It will be recalled that enjoyment of school was identified during earlier analysis using simple bivariate correlation coefficients (page 214) as being a likely significant factor, and also that these correlation coefficients had indicated that attitudes to school were important in their effects on attitudes to science. Attitudes to school clearly play a very important part in attitudes to science, since after regression, which controlled for many school-related variables, enjoyment of school was still found to explain the largest part of the variation in attitudes to science. Thus, any variables that are known to affect school attitudes are also likely to affect attitudes to science.

The second important point relates to the strong correlations found between the three attitudes: enjoyment of science, difficulty of science and difficulty of science written work, discussed in Chapter 4. The close links between these three sub-scales make it essential to look at the regression analyses for them as one group. In Table 5 –7, below, the results from these three sets of analyses have been summarised. The significant predictor variables for each of the attitudes in each of the years and the predictor variables for enjoyment of school are placed alongside each other, allowing comparisons to be made.

Table 5-7: Summary of the significant variables for attitudes to science and school

REGRESSION BLOCK	Enjoyment of science		Difficulty of science		Difficulty of science writing		Enjoyment of school	
	Year 6	Year 7	Year 6	Year 7	Year 6	Year 7	Year 6	Year 7
CHILD	Gender				Gender	Gender	Gender	Gender
							Asian	
SCHOOL	Year 6 intake	Time-tabled time available for liaison		One or more A-G grades	Year 6 intake			% with five or more A-G grades
				Selective school				
		CASE scheme		CASE scheme		CASE scheme	Topic approach	
		SALTERS scheme						
TEACHER	Length of non-teaching employment	Length teaching employment	Length of non-teaching employment					
			Length teaching employment					
	F1	F3		F3				
		F2						
CLASSROOM ACTIVITIES	Collaborative activities	Collaborative activities		Collaborative activities				
		Standardised activities		Standardised activities				
		Teacher directed activities	Teacher directed activities	Teacher directed activities				
SCHOOL ATTITUDES	Enjoyment of school in year 6	Enjoyment of school in year 7	Enjoyment of school in year 6	Enjoyment of school in year 7	Enjoyment of school in year 6	Enjoyment of school in year 7		
	Enjoyment of schoolwork in year 6	Enjoyment of schoolwork in year 7			Enjoyment of schoolwork in year 6	Enjoyment of schoolwork in year 7		

Some of the predictor variables are common to two or more of the dependent attitude variables, namely: gender, the use of particular schemes of work, school structural variables, the teachers' views about science teaching, their teaching and non-teaching experience, and finally the frequency of certain types of classroom activity, in particular the use of collaborative activities.

It will be recalled that because the three science attitudes (enjoyment of science, difficulty of science and difficulty of science writing) are very closely related, they could be regarded as part of an 'attitude to science' structure (page 216). Therefore, altering one variable, which has been found to affect one of these attitudes, is likely to affect the other attitudes in the longer term. So, the discussion that follows will take each of the important variables in turn, and discuss the effects of each on the overall 'attitudes to science'.

5.2 Factors influencing children's attitudes to science.

5.2.1 GENDER

Data from the present study, when used to provide either simple bivariate correlation coefficients or partial correlation coefficients, support the accepted view of significant relationships between gender and attitudes to science, in both years 6 and 7. These simple, uncontrolled analyses suggest that boys enjoy science more than girls, but that girls have less difficulty with the written work in science. But, the regression analyses indicate that the gender gap is much narrower than has been supposed, in particular for the enjoyment of science. Although gender is a significant variable in relation to enjoyment of science in year 6 (Table 5-1), this is not the case in year 7 (Table 5-2). These data suggest that, after transfer, differences between the attitudes of boys and girls are related to other factors and not specifically to gender. Furthermore, the results for the regression analyses of the 'difficulty of science' in years 6 and 7 (Tables 5-3 and 5-4) indicate that gender is not a significant variable, and for the 'difficulty of science written work' girls are more positive than boys, in years 6 and 7 (Figures 5-1 and 5-2, below).

These findings suggest that gender differences in attitudes to science might be affected by other variables, which have changed as a result of the transfer process.

Figure 5-1: Scores on the difficulty of science writing scale for girls and boys in Y6

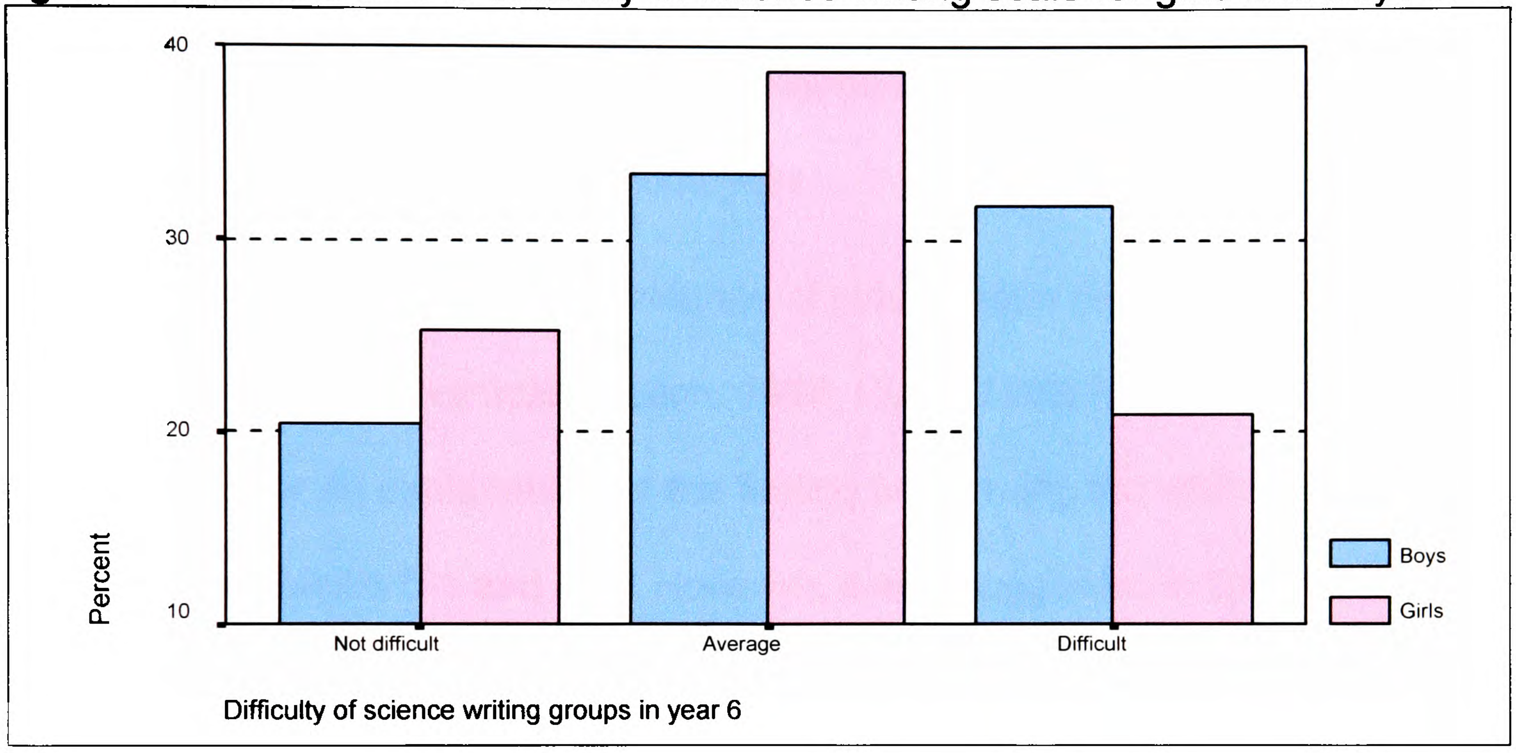
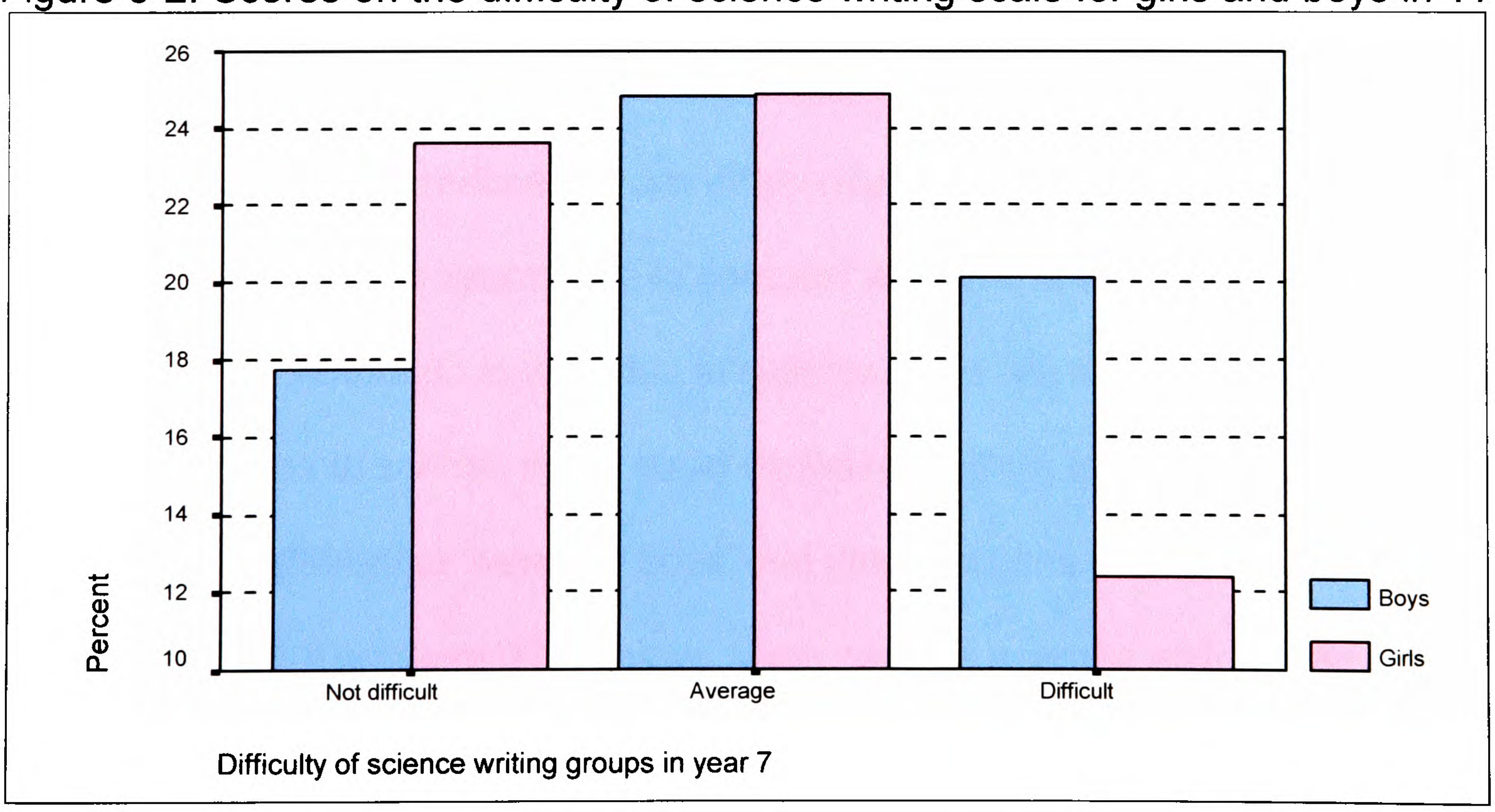


Figure 5-2: Scores on the difficulty of science writing scale for girls and boys in Y7



On examining the written comments of boys and girls, in Chapter 6, it seems likely that the factors affecting their enjoyment are different; the girls associate enjoyment of science with teacher quality, whereas the boys enjoy science more because of the increase in practical work. In addition, their written comments suggest that the socio-economic background of the school might be relevant. These factors are included in the regression analyses and might be important in explaining the much smaller difference between boys and girls in enjoyment of science in year 7 than in the previous year.

The well-documented evidence of girls' greater enjoyment of, and skill in, writing generally (for example, Bleach, 1998; Clark, 1998; Murphy & Elwood, 1998) may offer an explanation for the finding concerning the difficulty of science written work (Tables 5-1 and 5-2). However, it was suggested in Chapter 4 (page 203), that reasons for finding difficulty with written work in science might be connected more with an understanding of science than with literacy skills. Since very few girls appear to find science written work difficult after transfer, it is possible that girls feel better able to understand science after transfer and that this change is sufficient to reduce the sex difference.

At this point it is informative to consider attitudes to school, which make such an important contribution to attitudes to science. Girls are likely to have more positive attitudes to school, and it could be these feelings about school that minimise the differences between boys' and girls' attitudes to science on transfer. Figures 5-3 & 5-4 on page 290, below, show how the average attitudes to science for boys and girls are affected by their attitude to school. Children have been grouped according to their enjoyment of school score, which has a range of 1-5.

Thus, all those in the positive group scored above 3.5, and those in the negative group scored below 2.5; children in the neutral group scored between 2.5 and 3.5.

Boys do, on average, have more positive attitudes to science, whether their attitude to school is positive, neutral or negative. But, girls' average attitudes to science are closer to those of boys when their attitudes to school are more positive, particularly after transfer. Therefore, the lack of any significant sex difference after transfer might be the result of girls' generally greater enjoyment of secondary school, as well as their greater facility with science written work.

Figure 5-3: Scores on the enjoyment of school scale for girls and boys in Y6

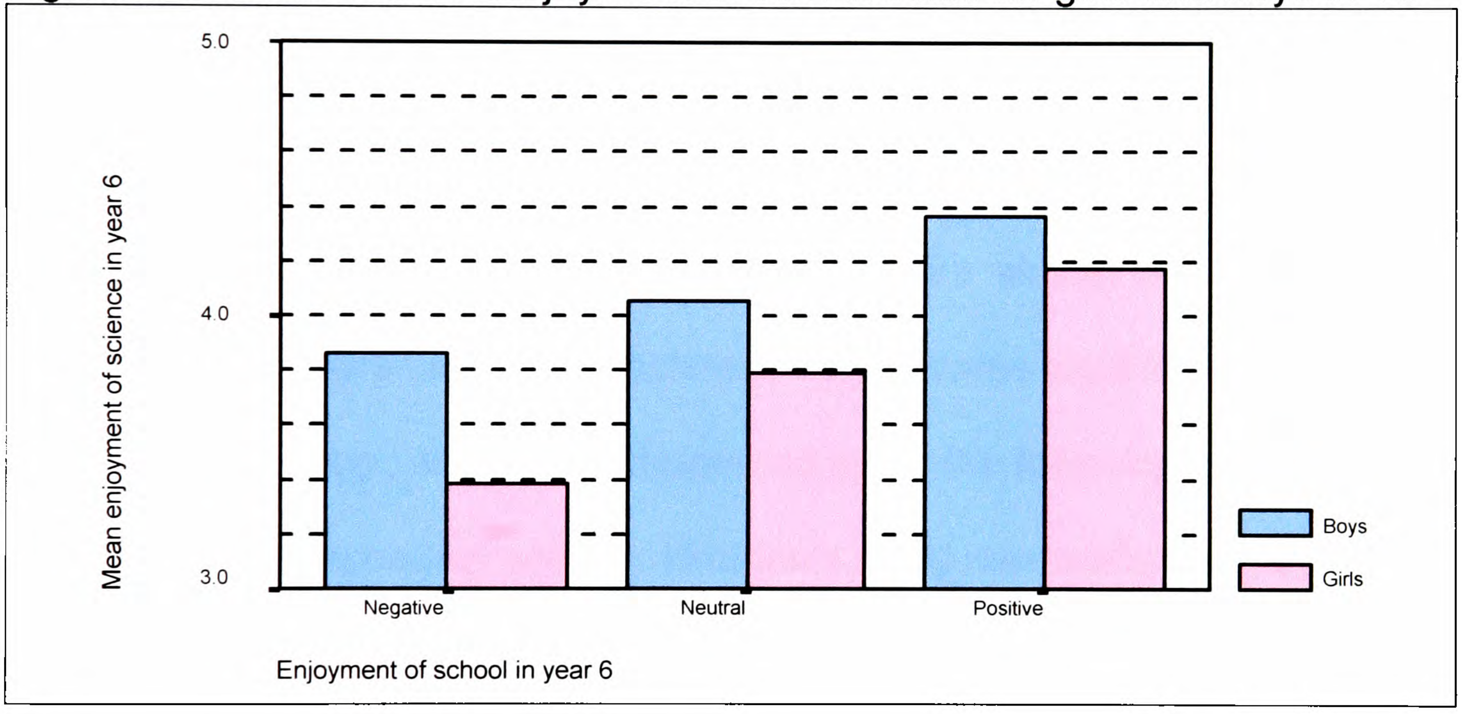
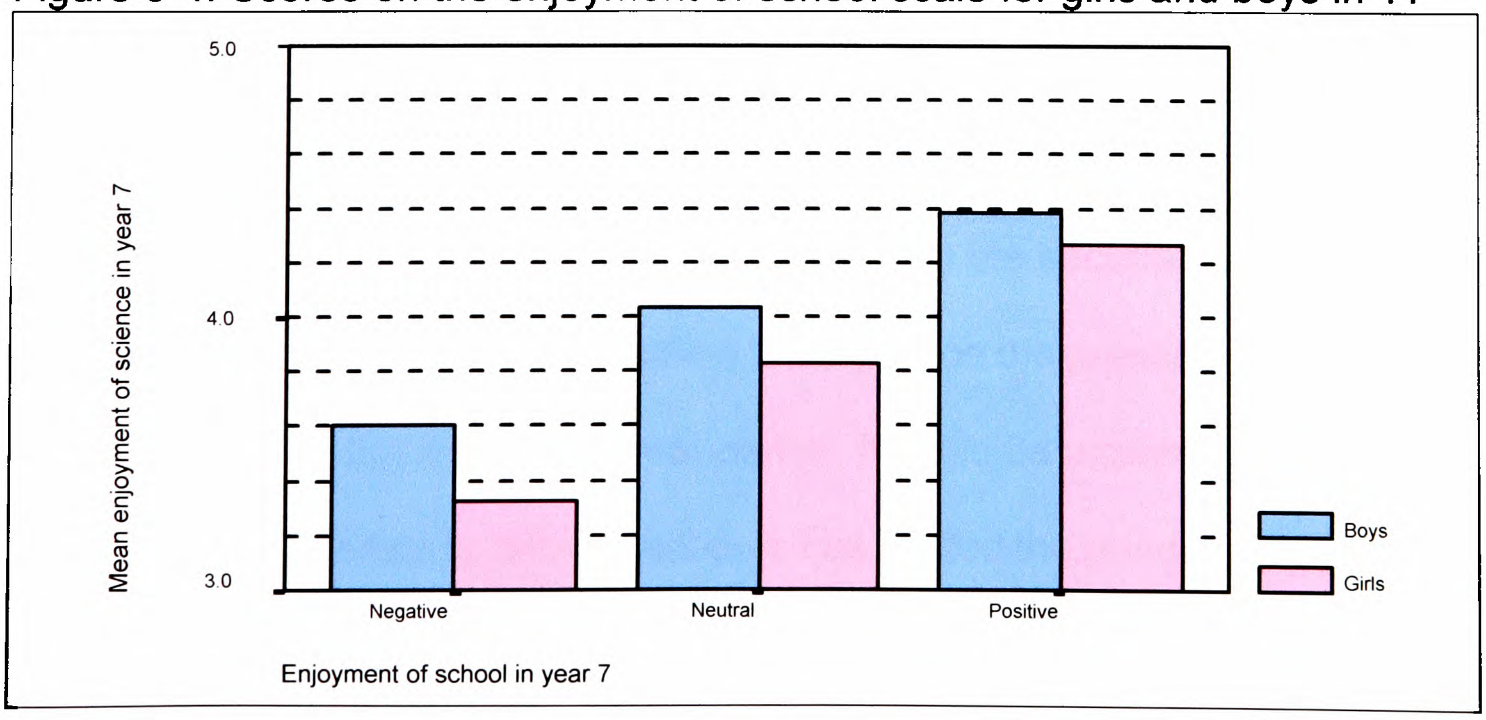


Figure 5-4: Scores on the enjoyment of school scale for girls and boys in Y7



On the other hand, since girls tend to be more positive about school as well as written work (Barber, 1994; Keys, Harris & Fernandes, 1995) it could be argued that the element of written work in science is linked with school in general rather than with science in particular. As such, this disappearance of a sex difference is not of particular relevance for *science* but should be seen as a more general, school issue. Certainly the 'science' variables explain very little of the variation in attitudes to written work and this may be explained if science lessons and science activities are not the main cause of the observed variation in attitudes to written work.

Hadden (1981), using similar methods to those in this study, found that girls' attitude to science declined more than boys' on transfer. Furthermore, he observed that although the gender differences were 'almost non-existent' in the data from the children in primary schools, they became significant in the first year at secondary school, and then disappeared again the following year (i.e. in the second year at secondary school). Hadden's study was made before the introduction of the primary science curriculum and he notes that,

> *...the teaching of science in primary schools is confined to a few isolated enthusiasts* (Hadden, 1981, p.22).

But the following year, *after exposure to science lessons*, girls' attitude to science declined *less* than boys' attitude. This produced a situation in which Hadden was unable to find any significant gender differences in the second year at secondary school. This is a particularly interesting finding since the present study encounters the same finding, but it comes a year earlier. It could be argued that the introduction of science to primary schools has *shifted* the gender differences and that once girls have had experience of the science curriculum their attitudes change less than before[1].

This argument is partially supported by the work of Woodward and Woodward (1998) who observed that in the period from 1991 to 1995, girls (in their last year at primary school) naming science as their favourite subject had increased from 1.7% to 5.0%. For boys the change was less, from 6.7% to 8.3%. Although not statistically significant, these results imply that the introduction of a primary science curriculum may have increased positive attitudes toward science among girls of this age.

Craig (1987) appears to offer contradictory evidence, finding that girls' interest in science dropped more than that of boys on transfer. However, interest in science and enjoyment of science are not identical. Certainly the questions asked examined a slightly different area from that of the current research. Furthermore the sample used was smaller and could not be considered to be a random sample, and so, although average values were compared, no statistical tests were applied. More recently an Australian study obtained results similar to those produced by Craig (Speering & Rennie, 1996). The sample was very small and not random (three primary schools in a middle-class area) but, in this study, children were asked not only about their interest but *also* about their *enjoyment* of science. It is noteworthy that the Australian data shows girls' interest in science falling more than boys' interest on transfer to secondary school, but their enjoyment falling less. In other words it supports both the findings of Craig and those of the present

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[1] This change in experience is less likely to apply to boys, since there is considerable evidence to suggest that boys are more likely to have encountered science though hobbies and clubs and in the home (Harlen, 1988: Vlaeminke, McKeon, Comber, & Harding, 1997).

research. So it seems likely that Craig's study does not offer contradictory evidence but instead was concerned with a different aspect of science attitude.

Recent attitude theory could also be seen as offering support for the view that greater experience of science is likely to affect attitudes to it, arguing that 'priming' and relevance are vital for attitude change (Fazio, 1990). It will be recalled from Chapter 2 (page 44) that 'priming' is thought to activate an attitude by giving experience or information about the subject; hence primary science could be considered as a 'priming' of 'attitude to science'. Since the systematic thinking mode, which allows greater openness to and persistence of attitude change, is "turned on" by relevance and comprehension (Chaiken et al, 1989; Petty & Cacioppo, 1996), children who understand the change in science teaching and appreciate its relevance are more likely to have a positive change in their attitude. Following this theory, attitudes to science are more likely to change if the children already have some experience of science, which 'primes' their attitude. Since girls were less likely to have experience and knowledge of science than boys, before the introduction of compulsory primary science, then boys rather than girls were more likely to be 'primed' by previous experience. However, with the introduction of primary science the proportion of girls having experience and knowledge of science would have increased and hence many more girls were also likely to have a 'primed' attitude to science. Such an argument may explain the disappearance of a gender difference after transfer.

An alternative explanation of the observed difference centres on the methods of analysis of data, and in particular the control of other variables. Although Hadden made comparisons between science and other subjects, he did not attempt to control variables that might have affected these attitudes. In particular, no attempt was made to control attitudes to school, whereas Speering & Rennie (Op cit) controlled attitudes to school to some extent by choosing to study a group of children with positive attitudes to school. In another longitudinal study, Power (1981), using regression analysis to control other variables, noted that gender was a significant factor at primary school (boys being more positive), but at secondary school this difference disappeared. More recently, Houtz (1995), controlling for school, social and cultural variables, found no significant difference between attitudes to science for boys and girls in this age group. These findings offer support for those of the present study, and also underline the importance of the control of variables.

5.2.2 The CASE scheme

The schemes of work used by different schools were included as variables in the regression analyses, but only the use of the CASE scheme appeared as a significant factor[1]. The use of this scheme is associated with *less* positive attitudes to science: children using the CASE scheme seem less likely to enjoy science, and more likely to find science and science written work difficult (Tables 5-3, 5-5, 5-7). These differences between attitudes for CASE and non-CASE pupils are shown in Figure 5-5 overleaf; scores for the enjoyment of science are lower for children using the CASE scheme, and scores on the two 'difficulties' scales are higher.

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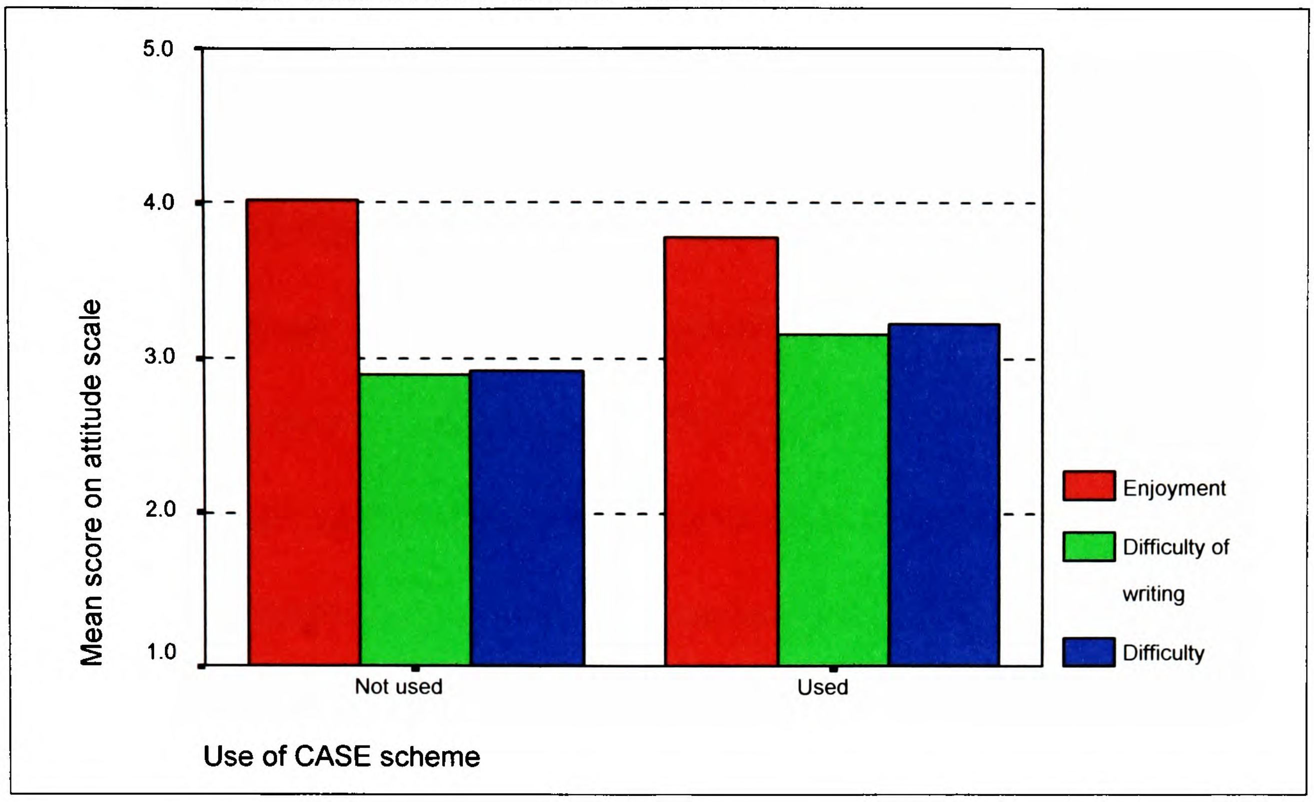
[1] In Table 5-3, the SALTERS scheme appears to be important because of the size of the change in R^2 and of the coefficient B, the F and t values are not significant (see Appendix 5).

Figure 5-5: Relationships between attitudes to science in year 7 and the use of the CASE scheme



These differences may have come about because of the use of the CASE scheme, but other explanations in terms of intake differences must also be considered: in particular differences in the intake pupils' attitudes to science and school, their individual abilities and their socio-economic background might all have affected their later attitudes to science.

Taking the first of these possibilities: differences between the intake pupils' attitudes in CASE and non-CASE school. Further investigation using independent sample t-tests indicated two significant differences: one relating to the difficulty of science, and the other concerning attitudes to school. Children who later used the CASE scheme had significantly different perceptions of the difficulty of science written work *before* transfer to secondary school. In particular, those who later went on to use CASE had found written work in science more difficult at primary school. At primary school there was no significant difference in school attitudes between children who would eventually use the CASE scheme and others who would not. But, once at secondary school, children using CASE were significantly more likely to hold negative attitudes to school than those not using this scheme.

The second explanation, differences in individual pupil ability, was not included in the regression analyses because the information was not available for all of the children. However, the effect of ability could be investigated for a sub-set of pupils, where schools provided CAT scores. Analysis of this limited number of CAT scores (52 pupils in CASE schools and 358 not in CASE schools) revealed that those children using the CASE scheme had a narrower range of scores (70 – 112) than those not using CASE (69-132), with a lower maximum level. These figures suggest that the CASE schools might have had a less able intake than the non-CASE schools.

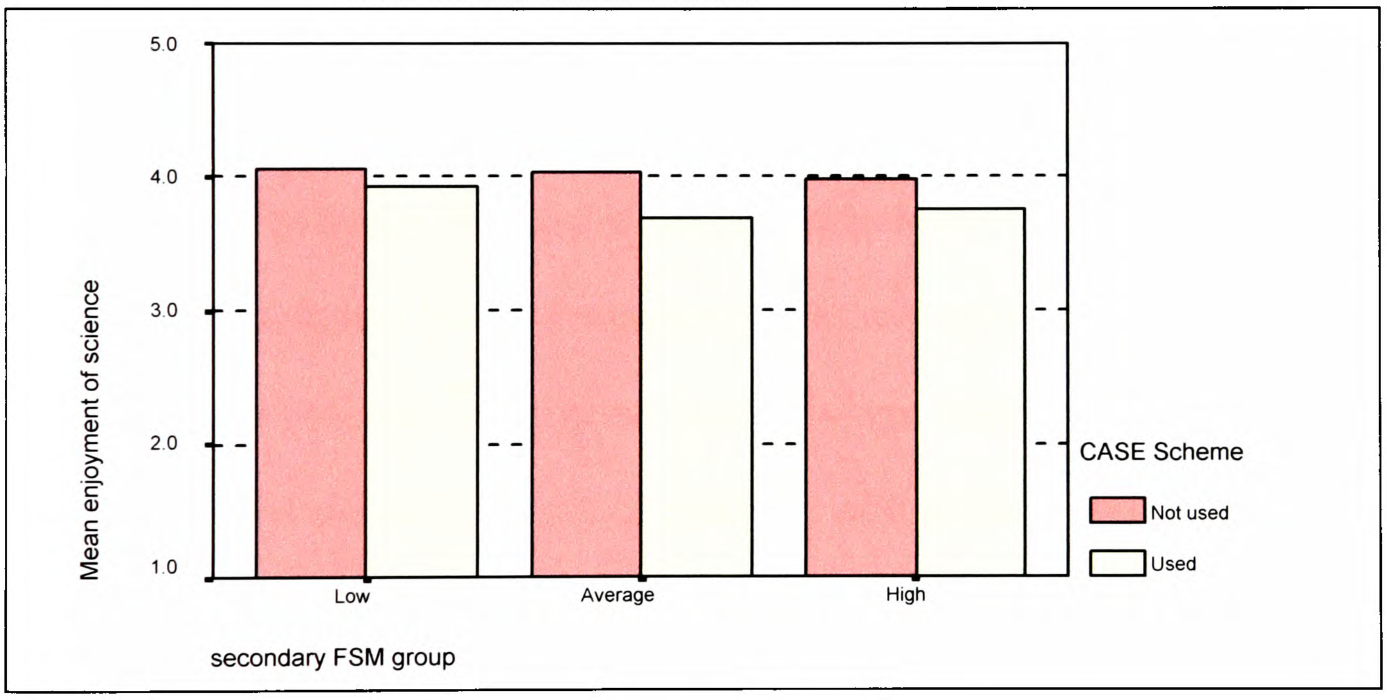
Turning to the last of these possible differences in intake characteristics: socio-economic indicators of deprivation were compared for CASE and non-CASE schools. A comparison of the school socio-economic indicators for CASE and non-CASE schools (free school meals, GCSE results, and the proportion of children with special needs and statements), suggests that, as a group, the children going on to a school where CASE was used may have been disadvantaged in comparison to those children going to non-CASE schools (Table 5-8).

Table 5-8: Comparison of school variables for CASE and non-CASE schools

	No CASE		CASE	
	N	Mean	N	Mean
% with five or more A-C grades	1925	43.34	333	38.18
% with five or more A-G grades	1925	90.69	333	91.48
% with one or more A-G grades	1925	95.35	333	96.01
% with statements	1897	1.53	333	1.90
% with special needs	1897	12.69	333	15.73
% free school meals at secondary school	1897	13.21	333	14.30
% level 4 or above in 1996 SATs tests	1909	63.02	333	64.09
% free school meals at primary school	1923	17.64	333	19.85

CASE schools had a lower proportion of pupils gaining 5 or more GCSE passes at A-C level, a higher proportion of children with special needs and statements, and a higher proportion of children taking free school meals. The primary schools from which these children came also had a lower proportion of pupils gaining level 4 or higher in end of key stage tests, as well as a higher proportion of children taking free school meals. Since the present research indicates a link between attitudes to science and the socio-economic area of the school (page 309), then children in CASE schools, in less affluent areas, may feel less positive about science, and this relationship is shown in Figure 5-6, below.

Figure 5-6:Relationship between enjoyment of science, CASE and free school meals



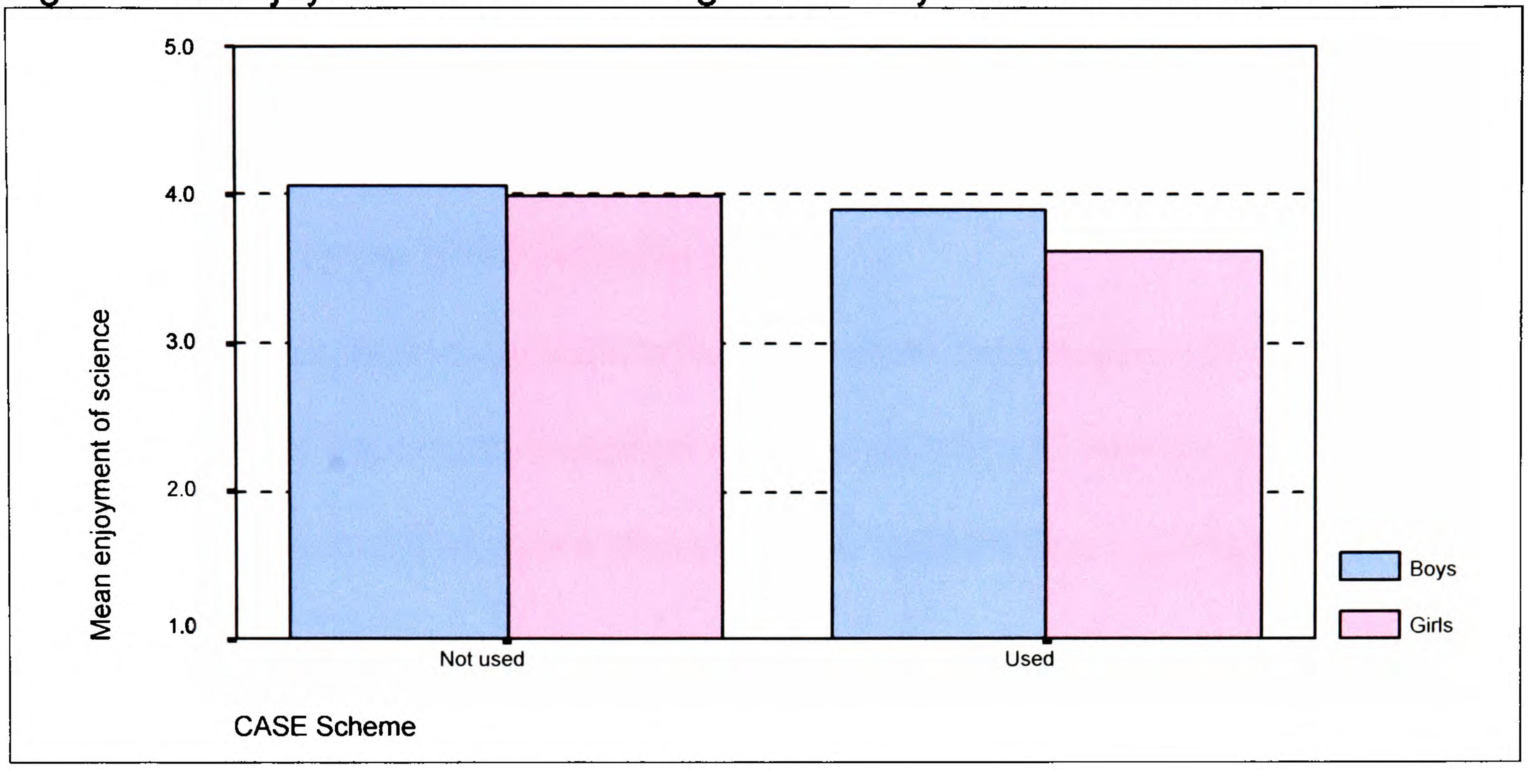
When all of this evidence is considered it seems possible that that the children moving to those schools using CASE might have been disadvantaged in terms of background or ability. Furthermore, since that group of children found science written work more difficult at primary school, they may have begun secondary school feeling less able to understand science and feeling slightly more negative about science than the 'non-CASE' children.

It will be recollected from Chapter 2 that there is evidence that using the CASE scheme can improve later pupil achievement (Adey, Shayer and Yates, 1989a). But there are also indications that some pupils benefit more than others, and two suggestions have been offered to explain these differential benefits: motivational style (Leo and Galloway, 1996), and context, in particular the effects of the use of group work. (Jones and Gott, 1998).

Turning first to the issue of motivational style, research findings have linked the transfer to secondary school with a sharp decline in pupils' feelings of competence (Leo and Galloway, 1996), and Rogers et al (1994) have shown that there is an increase in learned helplessness and a decrease in mastery orientation (for Mathematics and English) at the time of transfer to secondary school. In addition, American research, for a comparable school transition point; have found a relationship between feelings of competence and motivational style (Wigfield and Eccles, 1994; Harter, 1996). Intrinsic motivational style was higher where perceived competence was higher. Such findings could explain the decline in attitudes for the present sample of children, who already had lower perceptions of competence in science before transfer to secondary school.

Research, such as that of Dweck (2000), indicates different attributional and motivational styles for girls and boys, but Eccles (1985) and Rogers et al (1998) have found no clear gender difference in motivational styles. The present research finds a difference in attitudes to science for boys and girls in CASE and non-CASE schools (Figure 5-7). Enjoyment of science is less for both boys and girls in CASE school. But the difference in enjoyment of science in CASE and non-CASE schools is larger for girls than for boys, suggesting that girls might find the CASE scheme less acceptable than do boys. Whitelegg (1996) has also suggested that girls do not enjoy the CASE scheme as much as boys do.

Figure 5-7: Enjoyment of science for girls and boys in CASE and non-CASE schools.



Textual analysis of the present data showed that girls were more likely to comment on the difficulty of science lessons if they were in CASE rather than non-CASE schools (20% of CASE girls, and 13% of non-CASE girls) whereas for boys the proportion of such comments in CASE and non-CASE schools was very similar (9%), and lower than for girls (see Appendix 6). Furthermore, when boys using the CASE scheme spoke about the difficulty of science they used a more positive tone, as these typical examples illustrate,

> * 1186 *I liked it better last year because science in this school is boring because we do to much listening and writing to be able to learn anything. And our teacher last year explained it a lot more clearly.* (girl)

> 1210 *Well at my old school science was easier. but I am under standing more here and I enjoy it more at [secondary school]. We do experiments here but we did not hardly do any at my old school. At science in our old school we done things like look at stuff and make modles but we do better things. (Boy,)*

Although the boys may find science harder, they appear to see the change as an enjoyable challenge, but for the girls it seems to be just harder. Since the CASE scheme emphasises challenge in the form of cognitive conflict, the more negative attitudes of these girls might reflect a more learned-helpless motivational style. But the available evidence, does not allow a firm conclusion to be reached about these differences in terms of motivational style.

However, statistical tests with the present data suggest that gender alone is not particularly important in relation to the enjoyment of science in CASE and non-CASE schools, but that interactions between gender and social class may be very influential.

Further investigation revealed that the greatest decline in attitude to science is among girls from more economically deprived areas in CASE schools (Figures 5-8 & 5-9), and that there is a statistically significant interaction between gender, FSM and the use of the CASE scheme (ANOVA, Appendix 5).

Figure 5-8: Enjoyment of science for boys by free school meals and CASE scheme.

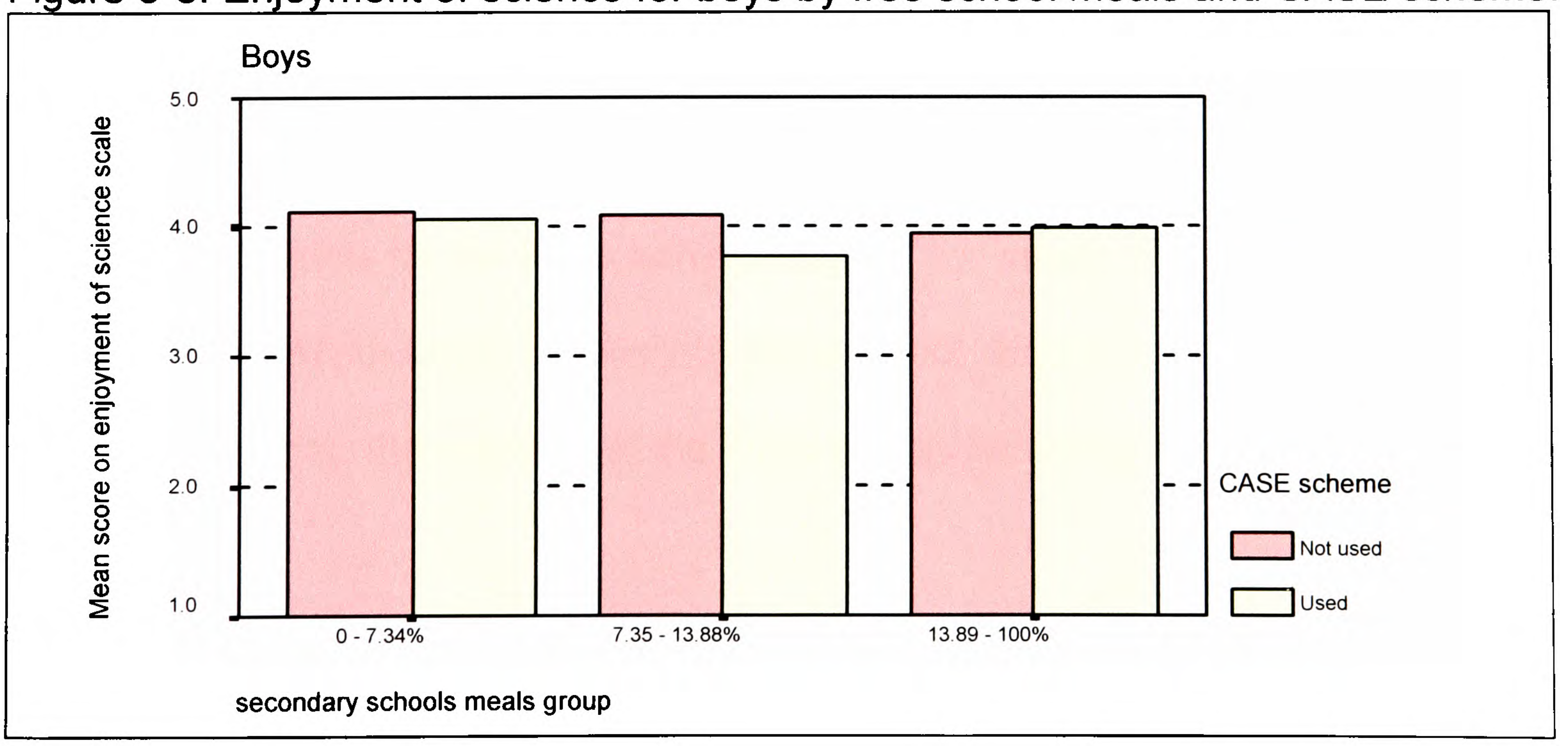
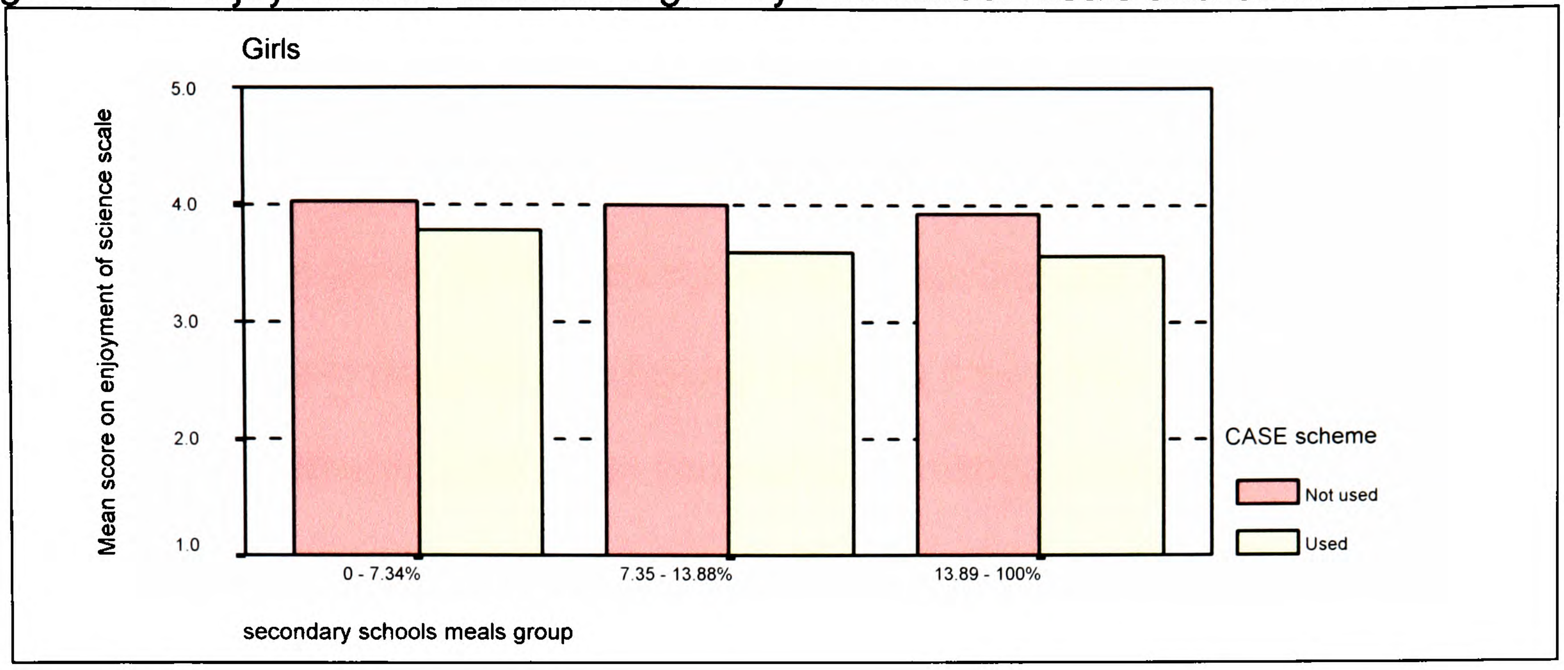


Figure 5-9: Enjoyment of science for girls by free school meals and CASE scheme.



As discussed in Chapter 2 (page 86), there is little research evidence on the interaction between gender and social background, but work by Domingos (1989) may offer an explanation for the observed difference for CASE schools. Domingos studied the conceptual demands of science courses, with 1300 pupils in Portuguese secondary schools, and found gender differences within social class; working-class girls performed less well than working-class boys, especially where higher levels of abstraction were required. She suggests that the conceptual demands made by teachers' are strongly influenced by the social context of the school; and that it is, in part, the lesser demands of the teachers that are responsible for the lower achievement of the pupils. This is an interesting idea, and one, which would certainly fit the evidence from the present study: where the teacher, the school and the socio-economic background all seem to be influential.

This idea is supported to some extent by recent studies showing differential approaches by teachers in disadvantaged and affluent areas in England (Osborn, 1997). Those teaching in disadvantaged areas were twice as likely to take into account the needs and socio-economic environment than were teachers in affluent areas. This sounds very commendable, but as well as showing greater concerns for personal and social development, these teachers were less concerned with academic knowledge. Such evidence could be interpreted quite differently: it may be that deprived areas do not attract such well-qualified and confident subject specialists. So two possible conclusions could be drawn from this evidence: either teachers (and others) make lower conceptual demands on working-class girls because of the social context, or less qualified teachers are less able to develop abstract concepts in working-class girls.

This brings us to the possible effects of context: Jones and Gott (1998) made two important observations about the effects of context in CASE and non-CASE schools: that social deprivation and negative attitudes towards learning might make the CASE scheme counter productive (social context), and that, in some schools, lesson structure did not appear to change on adoption of the CASE scheme, these 'naturalistic' schools did not necessarily adjust their approach to a more collaborative one (teaching context).

There is much in the research literature arguing that social context *has* an important affect on students' attitudes and on their achievements (Hennessy, 1993). White (1988) includes social dimensions in his definition of context, and makes a case for the amount of control and autonomy in the classroom as an important *context*. The position has more recently been argued by Wegerif and Mercer in 1997 cited in Wegerif et al (1999), taking the Vygotskian view of *'reasoning as a social process'*, which they investigated via the concept of 'exploratory talk'. Their results, with a small group of children, indicate that non-verbal reasoning can be mediated by social interaction, in particular, by the use of small and carefully organised group discussions. Kyriacou (1998) has indicated that co-operative activities are generally enjoyed by children and teachers, and that children learn by sharing ideas. These findings only serve to support earlier works such as those of Solomon (1994), that social interactions influence learning and development.

The CASE scheme has emphasised the Piagetian model, where learning depends upon intellectual maturity, and the influence of context was not discussed, although clearly evident in the prescribed teaching methods.

It could be argued that the context of the lessons is the crucial differentiating feature and that it is the learning style that is important rather than the use of the CASE approach within these lessons. Mercer et al (1999) have shown that pupils 'ability to reason and solve problems involving new information' increases when 'a teaching programme for 'scaffolding' children's effective use of language as a tool for reasoning' is introduced. The ground rules used in this programme are very similar to those used in the CASE programme, but the TRACS programme appears to pay more attention to social context.

Two major points emerge; first and generally, collaborative work is regarded as highly motivating and capable of improving levels of learning (page 94), and so it could be argued, that schools using the CASE scheme *should* see improvements in achievement because the teaching context (small group activities) is in itself motivating. Secondly, research has indicated that although collaborative contexts *should* be more supportive of and helpful to girls (Head, 1996; Fennema, 1996), the type and organisation of group-work and collaboration are critical (Wellington, 1994; Murphy et al, 1995; Hanrahan, 1998; Matthews, 2001). The CASE scheme should, by the very nature of its *context*, lead to some improvement for children using it, but, since girls do not appear to enjoy group-work as much as boys (Stark and Gray, 1999), girls may find such a scheme less congenial than boys. One of the very few references to group work in the present study, from children in CASE schools, concerned the conflict that may arise through collaborative work,

> **1244 In secondary school we learn a lot more than we do at junior school. We do a lot more experiments, work and homework. I some times find it quite difficult when we do experiments, because when we work in groups every one has different opinions so we end up arguing. (Girl, high FSM)*

As mentioned in Chapter 2 (page 97), girls may not always benefit from discussion in mixed groups where the choice of grouping is left to the children, and boys may make greater cognitive progress through such methods (Alexopoulou & Driver,1997)

Turning next to the observation made by Jones and Gott (1998): that some schools did not appear to adjust their approach to a more collaborative one on adoption of the CASE scheme.

The CASE scheme specifies small-group teaching (Adey, Shayer & Yates, 1989b), and there is ample evidence that such a teaching style increases feelings of competence and should lead to greater academic motivation (for example, Ames, 1992; Anderman & Maehr, 1994; Hymel et al, 1996). Therefore, it might be expected that the use of the CASE scheme, would ensure more discussion and small-group work. However, the success of the CASE scheme depends upon special training of teachers (Harlen 1999). Shayer has emphasised the special skills required:

> *Orchestrating or chairing his whole-class discussion so that six or seven working groups listen (and cross-question) each other – while the teachers try to 'get out of the way' themselves – is the principal class-management skill the teachers have to develop.* (Shayer, 1999, p.897).

Thus, the *context* of the CASE classroom should be different from that of an average non-CASE classroom *if* the training of the teachers has been successful.

For the schools in the present study, if the training of teachers has been effective then two things might be expected: the amount of 'group-work' experienced by pupils in these schools should be appreciably more than for pupils in 'non-CASE' schools, and the amount of teacher-directed work should be less. However, the present study does not indicate that either of these things occurs. There are strong indications that, for this sample of CASE schools, there was no greater emphasis on group work than for the non-CASE schools. When the children's questionnaire responses are considered, there is no significant difference between the two groups in terms of the amount of collaborative work reported, but the amount of teacher-directed work appears to be higher for the CASE group (See Appendix 5, Table 5-63 and Figures 5-1 & 5-2).

Children's reports of the amount of collaborative work in these secondary schools are not significantly different from those in schools not using the CASE scheme (independent samples t-test), in either Year 6 or Year 7. This apparent lack of difference in amount of collaborative working is not simply a reflection of the questionnaire item about the use of practical work. It is reflected in each of the items making up the overall collaborative working factor, there is no significant difference in reported amount of small group discussion or for discussion with teachers, for CASE and non-CASE students. Textual analysis reveals very few students in the CASE group commenting at all on the use of group work. In fact, out of 332 responses, only four comments about group work were recorded (1%), all from girls, whereas in the non-CASE group 51 comments about group work were made, (3% of all non-CASE students). Although the numbers are small, they certainly indicate a lack of awareness, among the 'CASE' group, of any increased use of group work.

Analysis of the teachers' owns views of their teaching, has indicated possible differences in approach for teachers in CASE and non-CASE schools (see Appendix 6) In particular, teachers in CASE schools say much more about knowledge and theory (86% of CASE teachers but only 62% of non-CASE teachers) and less about active working, such as experiential learning and discussion (10% of CASE teachers, but 16% of non-CASE teachers).
These differences could be a reflection of a change in approach brought about by the CASE scheme, but it is accepted that they could also result from the researcher's interpretation of the text. However, the quantitative data from the teachers' questionnaire indicates similar differences. Teachers in CASE schools score significantly higher on the 'the transmission of science as a body of factual knowledge' factor (t-tests, $p<0.001$), than do teachers in non-CASE schools. These qualitative and quantitative findings suggest that teachers in CASE schools are more concerned with theoretical, knowledge based teaching than are teachers in non-CASE schools.

Teachers in CASE schools also scored a little higher on the 'child-centred discussion' factor (t-tests, $p<0.05$), but this reflected their different views on 'helping children to construct their own explanatory models'; their views about 'providing opportunities for the discussion of children's own scientific ideas' were no different from those of non-CASE teachers. This finding may reflect the omission of an important collaborative aspect of the CASE scheme.

These differences suggest that teachers in CASE schools may be taking a different approach from those in non-CASE school: laying greater emphasis on the teaching of theory and the transmission of knowledge, but without any substantial increase in discussion and collaboration.

The present study could not identify those teachers *specifically* delivering CASE lessons, only those teaching in schools using the CASE scheme, but it is unlikely that *all* the teacher responses analysed were from those directly involved in teaching CASE lessons. So the data from the present survey relates to whole science departments rather than to the specially trained CASE coordinators, and leads to the tentative conclusion that the CASE schools in this sample may not have effectively transferred all of the prescribed CASE strategies into their teaching.

The suggestions by Jones and Gott (1998) that context is important appears to be supported by the present research: socio-economic deprivation does seem to make the CASE scheme counter-productive (particularly for girls), and the schools in this study do not appear to have made substantial moves towards more collaborative teaching methods.

In summary, it is suggested that the changes in attitude associated with the CASE scheme might be in part explained in terms of changes in motivational style on transfer from primary to secondary school, but, that the effects of context may be particularly relevant. Differences in terms of the pupils' socio-economic background, and in the training and classroom approaches of the teachers, may have important influences on the attitudes of the children.

5.2.3 SCHOOL VARIABLES

In year 6, both the enjoyment of science and the difficulty of science writing are significantly linked with the size of the year 6 roll (Table 5-1, page 284 and Table 5-5, page 285). These relationships are shown in Figures 5-10 & 5-11.

Figure 5-10: The enjoyment of science and the number on roll in year 6

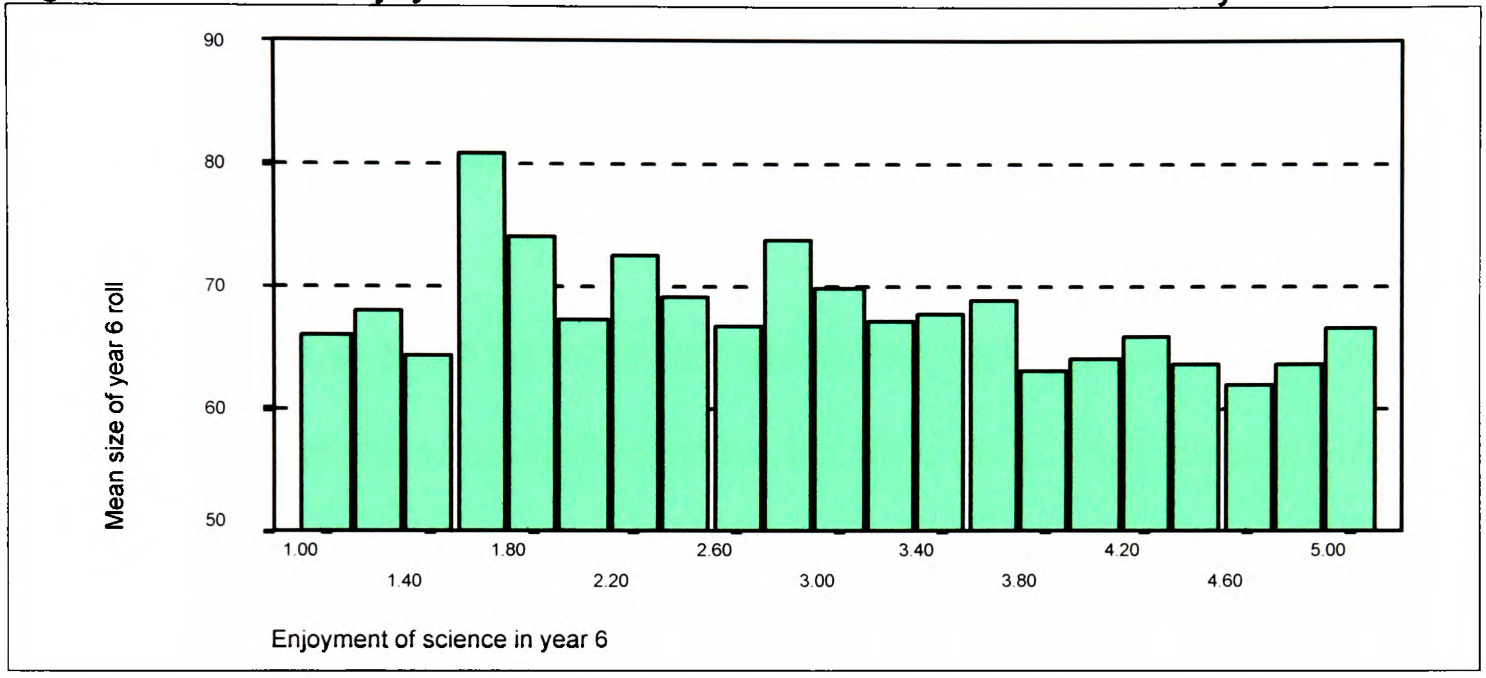
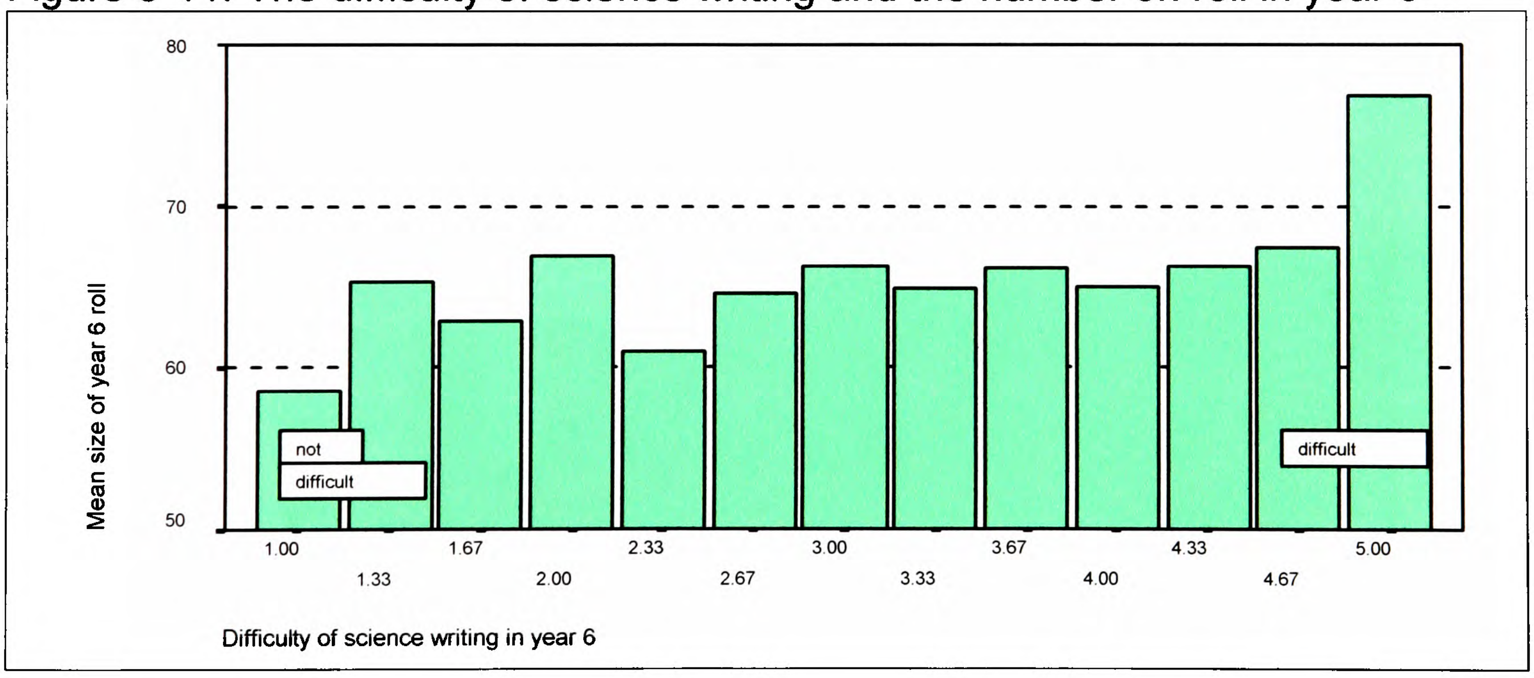
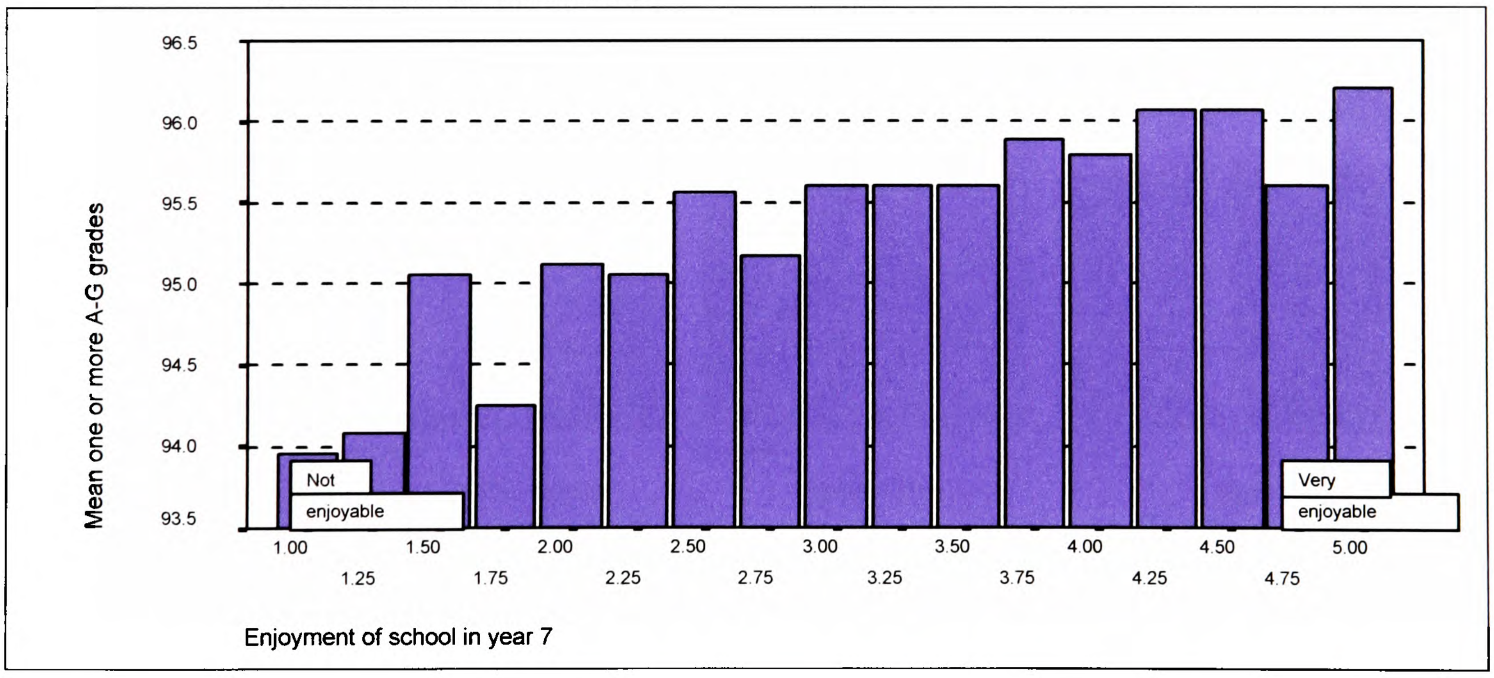


Figure 5-11: The difficulty of science writing and the number on roll in year 6



These findings indicate that children in smaller schools are likely to have more positive attitudes to science. But for each of these analyses both the R^2 change and the B value is small, which suggests that the size of the school alone has only a small contribution to make. However, smaller primary schools are likely to have lower free school meals requirements and also to have more examination successes (page 223), suggesting a link between attitudes to science and socio-economic background. In year 7 this link is more apparent, since the difficulty of science is significantly related to the school's success in GCSE examinations (Table 5-4, p.287). The values of the R^2 change and of B are also relatively large suggesting this may be an important effect. Children in schools gaining higher proportions of GCSE passes are less likely to feel that science is difficult. Furthermore, enjoyment of school at secondary school is significantly related to the examination success of the school (Table 5-11, page 328); this is shown in Figure 5-12, below. It will be recalled that examination success may be regarded as an indicator of the socio-economic background of the area (page 223), so attitudes to science might be related to the socio-economic background of the area; this issue is discussed further in Chapter 7 (pages 421-427).

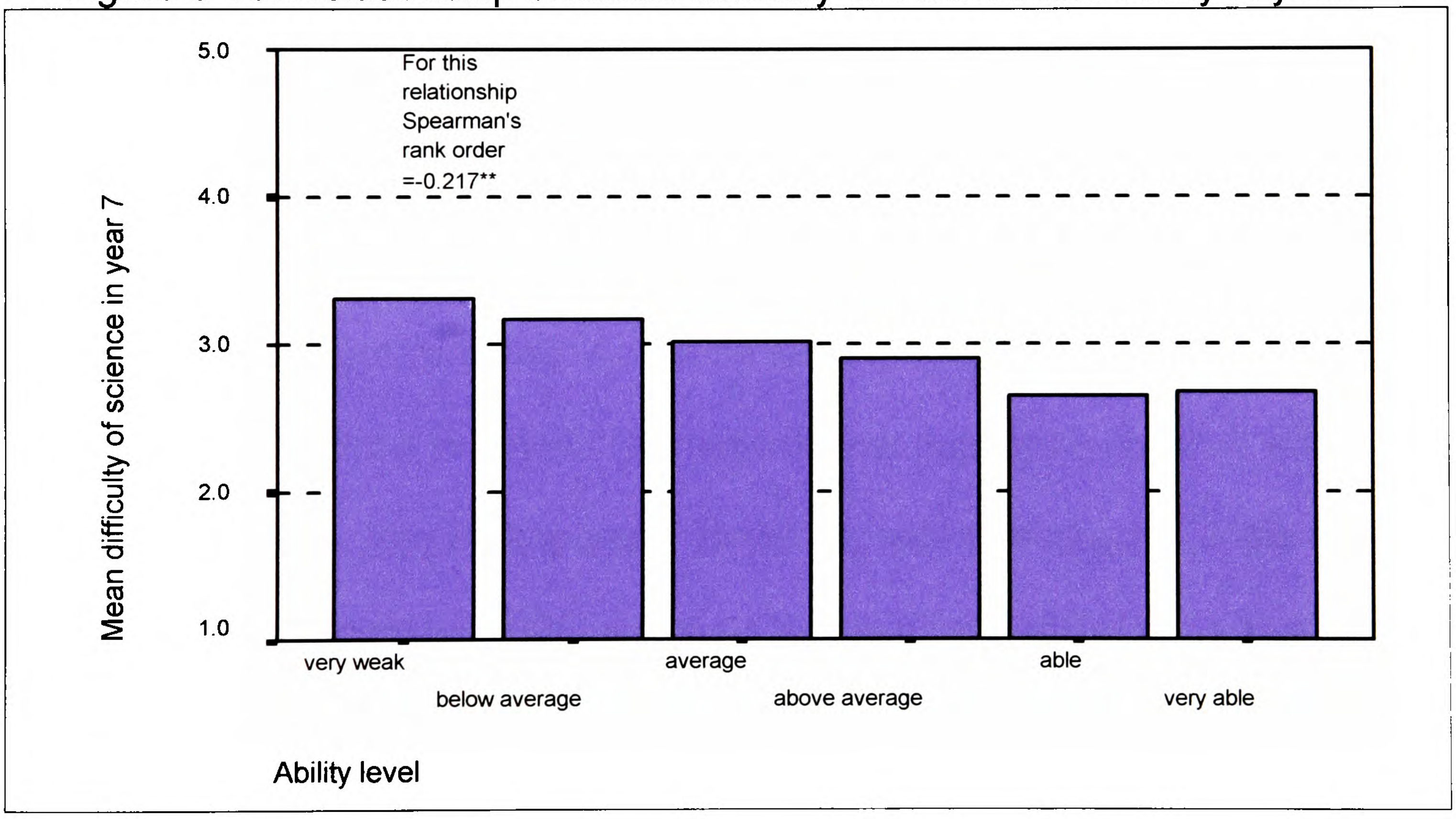
Figure 5-12: The enjoyment of school in year 7 and the school's GCSE examination success



On the other hand, small schools are more likely to use a topic-based approach, and this is one of the variables associated with greater enjoyment of school in year 6. So, it is also possible that greater enjoyment of science is more likely when a topic-based approach is used.

Finally, children in selective schools are likely to find science less difficult than those in non-selective schools. However, the size of the R^2 change and B coefficient indicate that this is likely to be a relatively minor effect. This might simply be related to ability, and the possibility was checked by using the information provided by a few of the secondary schools about the relative abilities of their year 7 groups (see Figure 5-13, below). There certainly seems to be a strong relationship between the two. Spearman's rank order correlation coefficient for this relationship is statistically significant ($p<0.001$) for a sample of 1220 of these children. However, not every school provided information about ability, so this finding does not represent the original random population.

Figure 5-13: Relationship between difficulty of science and ability in year 7



5.2.4 Teacher variables

Teachers' stated approaches to science teaching and their length of teaching experience appear to have important effects on children's attitudes to science.

However, it is also worth noting that teacher science qualifications do not appear to have any significant effect on children's attitudes to science.

In particular, teachers with lower science qualifications might be expected to have less subject knowledge and therefore less confidence in their teaching (Carré et al, 1989; Bennett et al, 1992; Harlen & Holroyd, 1996; Denley & Bishop, 1997; Finlayson, 1998; Young, 1998). Harlen (1996) has suggested that lack of confidence may lead to more expository teaching and an avoidance of all but the simplest practical work, so, at first sight, it seems surprising that science qualifications do not appear to influence children's attitudes to their science lessons. Although there is no clear link between the two, *some* links between teachers' training and experience, and their views about science and science teaching were found (page 280). It may be that these teachers' views and approaches are affected, to some extent, not only by their qualifications but also by their teaching experience, and therefore, qualifications do not emerge as statistically significant variables. As will be seen (page 361), children do talk about teachers' qualifications in a way that suggests that qualifications, or at least subject knowledge, may be important. However, recent research into the teaching of mathematics (Rowland, 2000) suggests that teachers' attitudes to maths, or their understanding of the fundamental ideas in maths, may be more important than their qualifications. Perhaps science teaching also depends more on attitudes to science and understanding of the nature of science than on qualifications.

Two types of teacher variables appear as significant for attitudes in both year 6 and year 7: the teachers' experience, either in terms of years of teaching or of non-teaching employment, and the teachers' views about the importance of certain teaching approaches in science. Although these variables individually make only small contributions to the overall R^2 value, their presence in primary and secondary school analyses and in both enjoyment of science and difficulty of science analyses (Tables 5-1 to 5-4), indicates that the teacher may have a substantial role in developing attitudes to science.

Children appear to enjoy science more in year 6 if their teachers have had *more non-teaching* experience (Figure 5-14, below), but at secondary level they enjoy science more if their teachers have had *less teaching* experience (Figure 5 - 15, overleaf).

Figure 5-14: The relationship between year 6 children's enjoyment of science and teacher's length of non-teaching employment

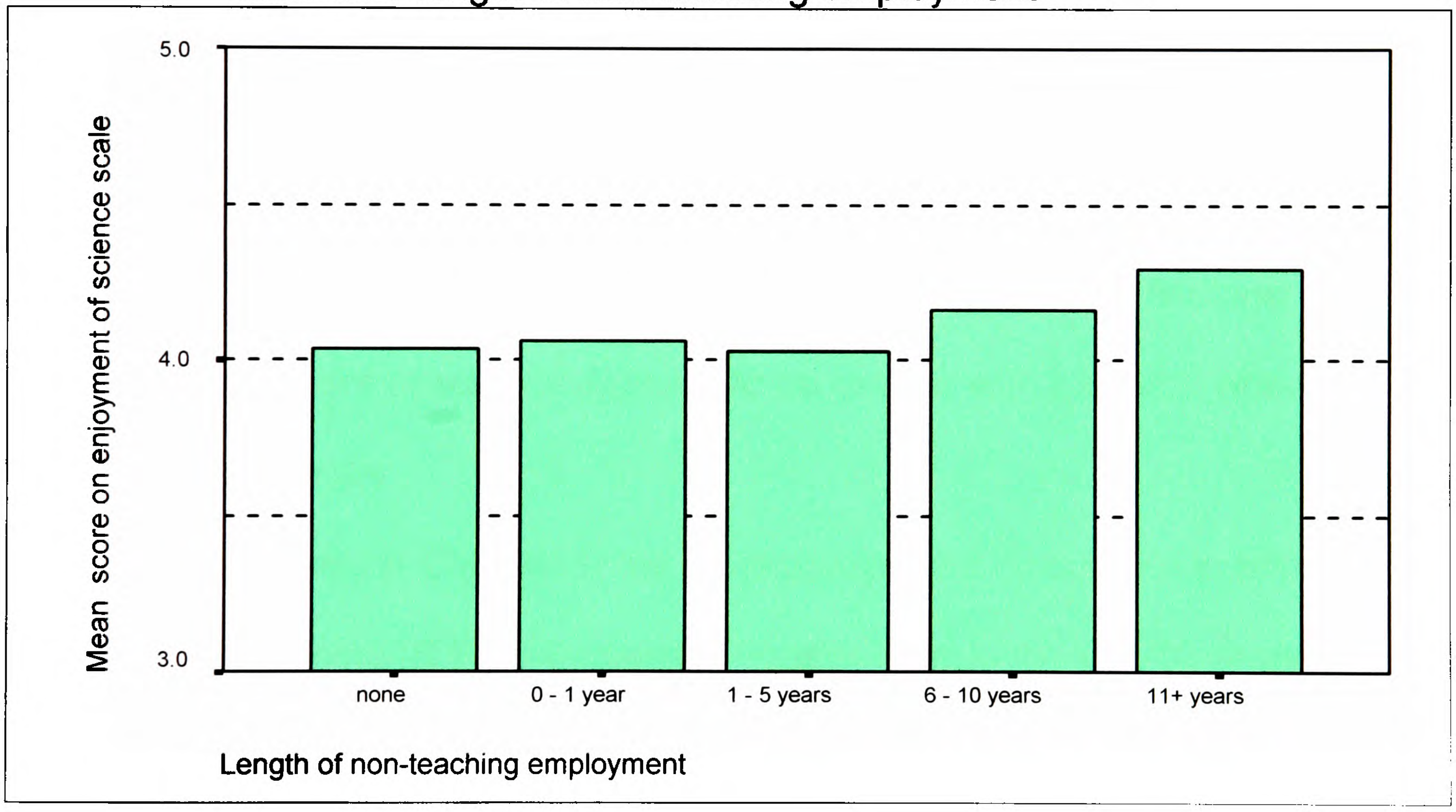
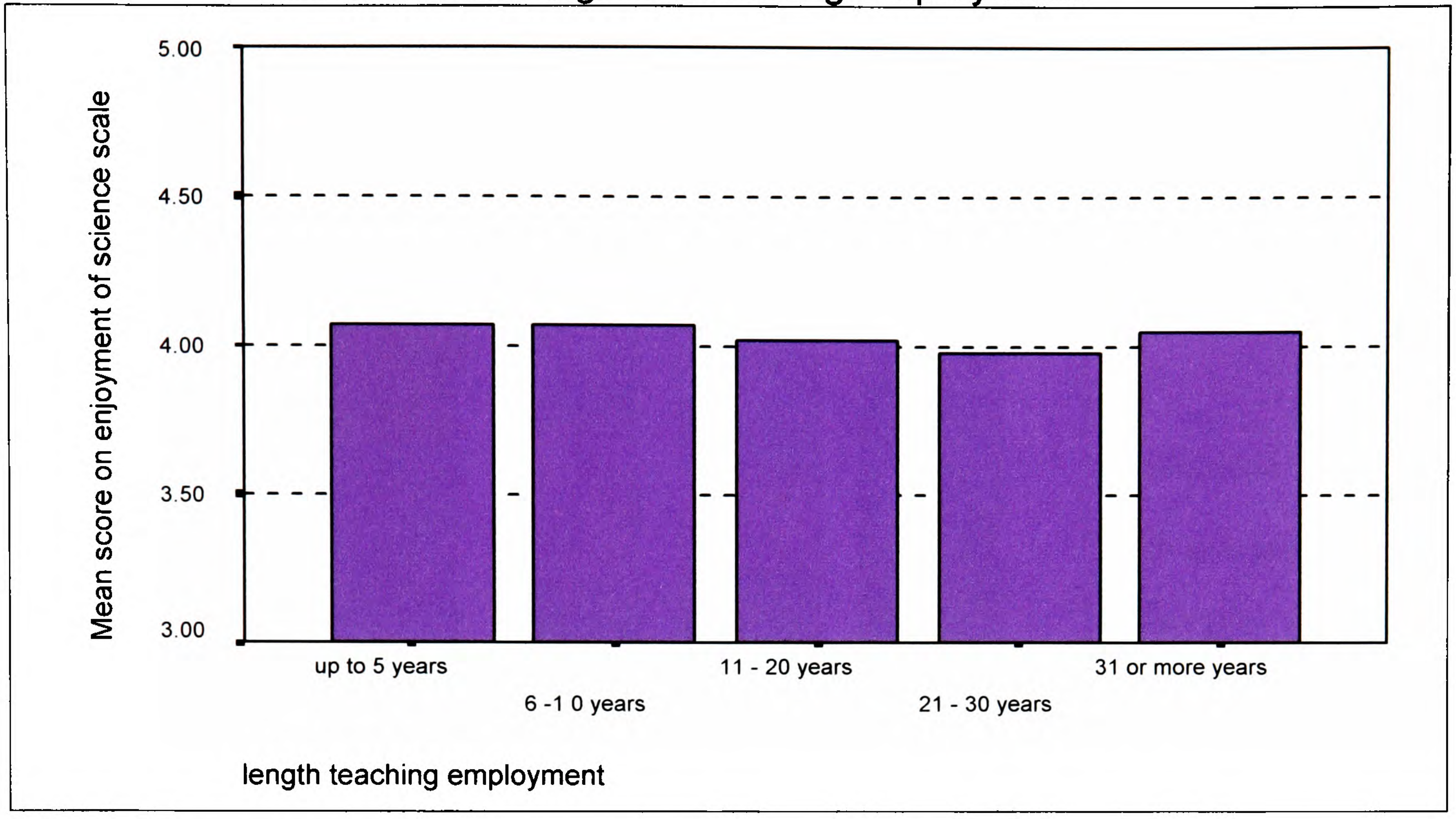


Figure 5-15: The relationship between year 7 children's enjoyment of science and teacher's length of teaching employment



Among this group of primary school teachers, those who had had greatest length of non-teaching experience were likely to have had the shortest length of teaching experience. Therefore, there may be some consistency in these findings: children's *enjoyment* of science appears to be greater with teachers who have trained more recently.

As discussed in Chapter 1, the emphasis placed on science in primary initial teacher training (ITT) has changed considerably in the last 10 years. Thus, primary school teachers with more than 5 years of teaching experience in 1995 would probably have had less science in their ITT courses. Therefore, it seems possible that those more recently trained teachers might come with more subject knowledge in science and hence more confidence in their ability to teach science. Indeed, the teachers with the higher qualifications tended to be those who had been teaching for the shorter lengths of time (Figure 5-16, overleaf) and those who expressed positive feelings about teaching science were likely to have been teaching for a short length of time and to have studied science beyond school level (Figure 5-17).

Figure 5-16: Relationship between primary teachers' length of teaching employment and their highest science qualification

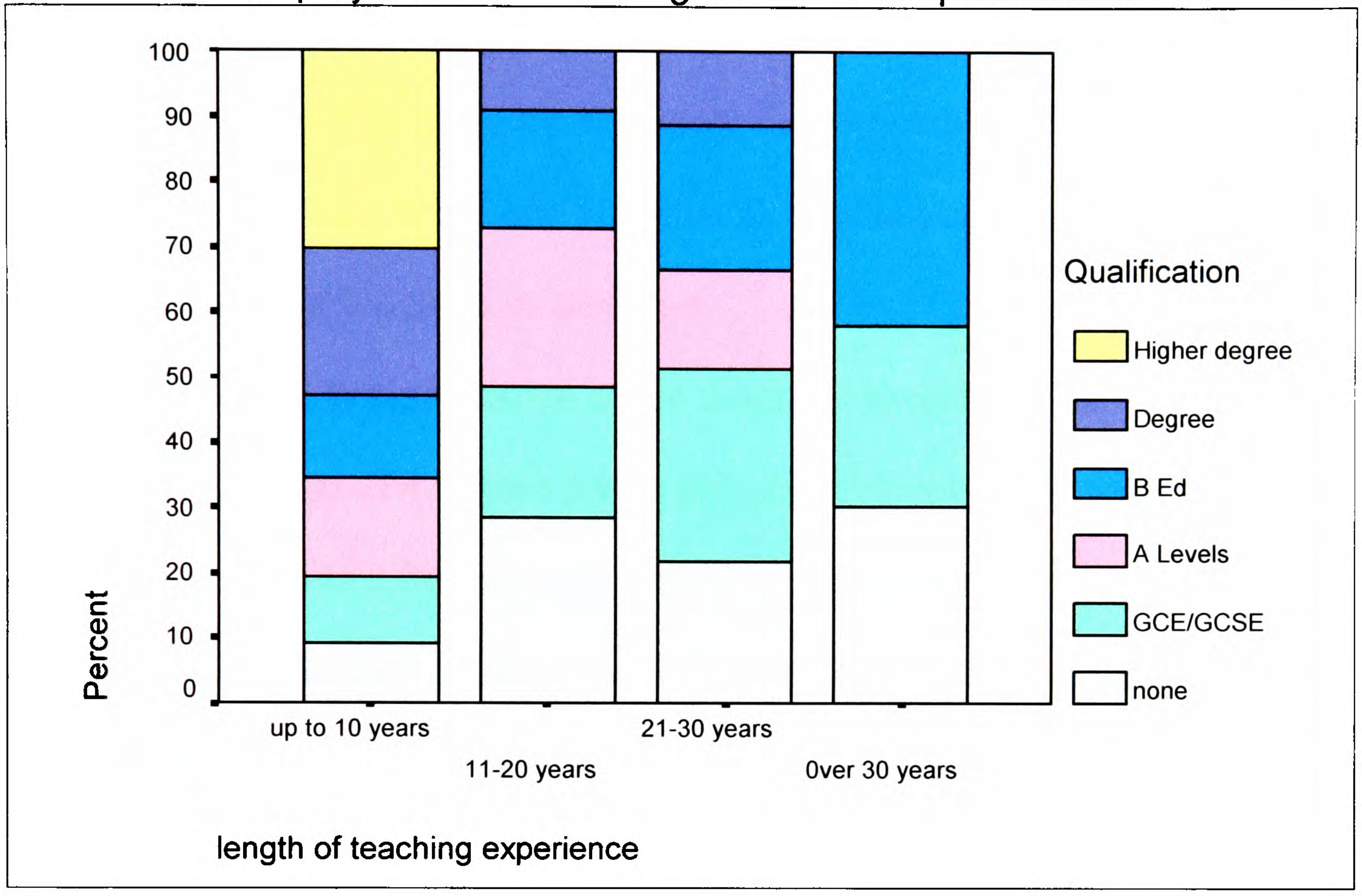
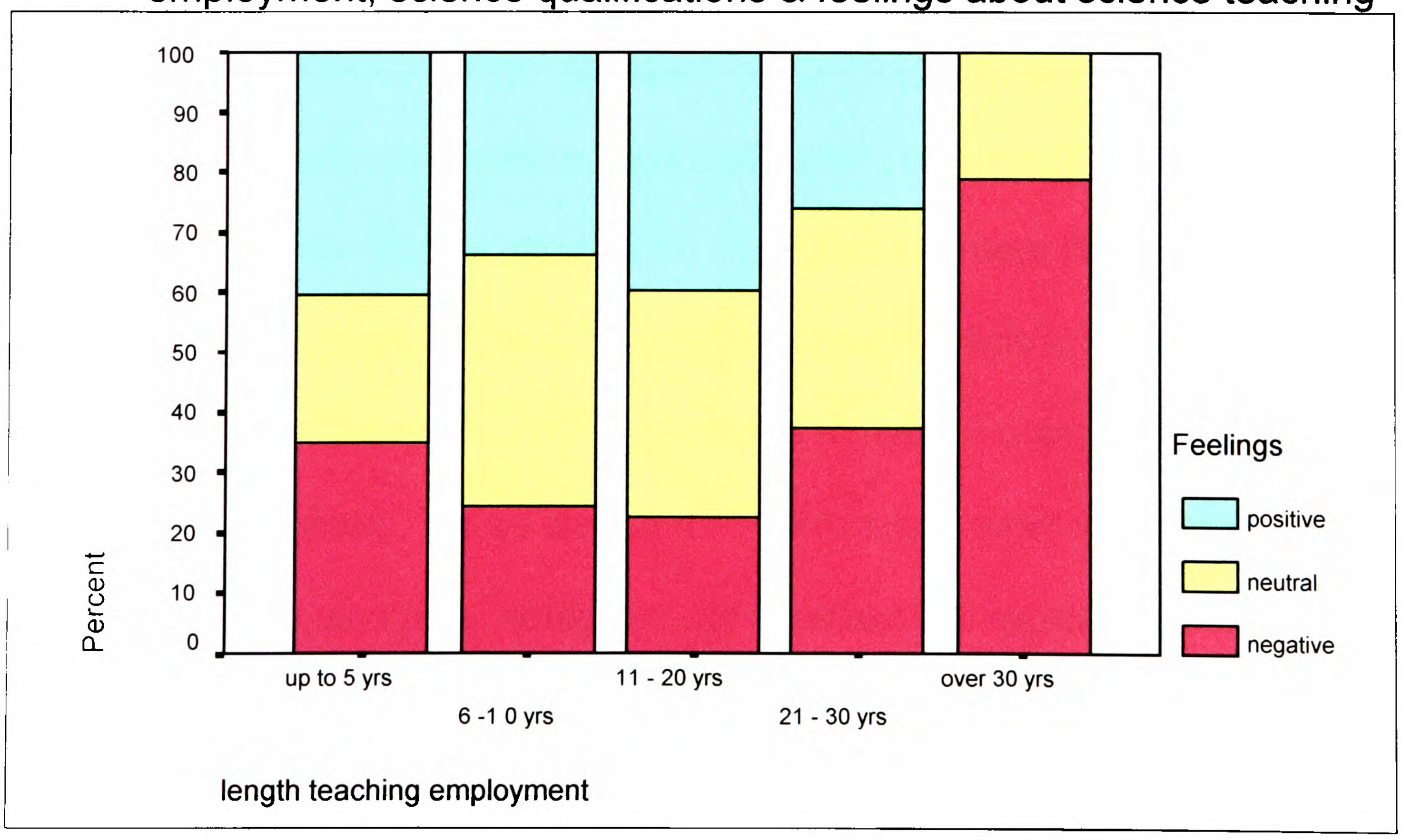


Figure 5-17: Relationship between primary teachers' length of teaching employment, science qualifications & feelings about science teaching



This explanation does not take account of the similar trend observed for secondary science teachers. However, teachers with the highest qualifications in science are likely to have taught for the shortest length of time (Figure 5-16, above), suggesting that the education in science might be the important factor. In addition, teachers who have trained more recently are more likely to have had training that explicitly deals with National Curriculum science; this may have affected their later teaching or attitudes.

The possible significance of the length of teaching employment was discussed on page 274, where it was suggested that teachers who trained more recently might have different approaches to science teaching; perhaps these differences in approach affect children's attitudes to science. On the other hand, Year 6 children whose primary teachers have had more experience in either teaching or non-teaching employment see science as less difficult, suggesting that increased experience improves pedagogical skills (Table 5-3, page 284).

Teachers' views about what is important in their approach to science teaching also appear to have significant effects on children's attitudes. At primary school, children whose teachers think that it is important to pass on knowledge and to give children factual information (f1 factor) are more likely to enjoy science (Figure 5-18, overleaf). At secondary school, children whose teachers feel that it is important to take a child-centred approach (f3 factor) enjoy science more (see Figure 5-19, overleaf). These are the very factors that differ significantly between teaching sectors, and thus, could be said to reflect the approaches to science teaching within primary and secondary schools.

Figure 5-18: Relationship between year 6 children's enjoyment of science and teacher's score on the knowledge factor

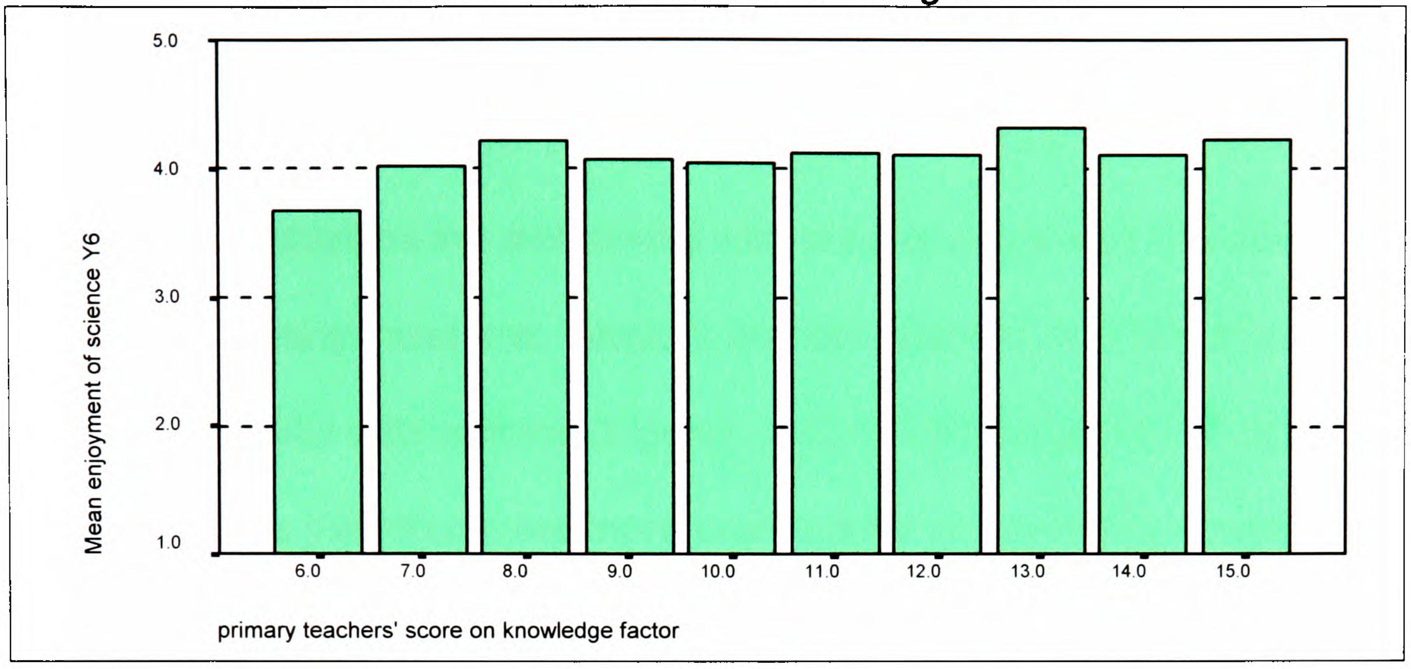
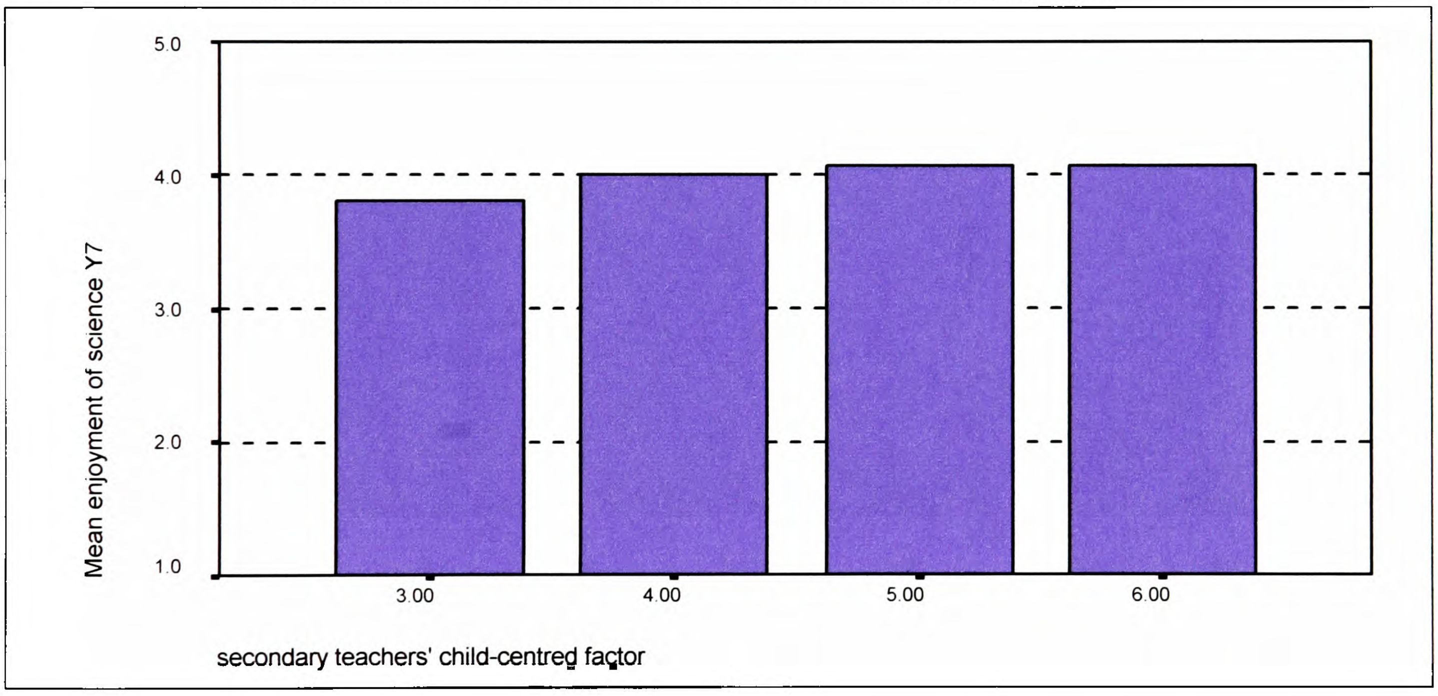


Figure 5-19: Relationship between year 7 children's enjoyment of science and teacher's score on the child-centred factor



It will be recalled from Chapter 4 (page 247), that primary teachers are significantly *less* likely to regard the knowledge factor (f1) as important, but that secondary school teachers are significantly *less* likely to regard the child-centred factor (f3) as important. So it seems likely that children enjoy science more with teachers who combine these two approaches. In addition, children at secondary school with teachers who believe that the child-centred approach is important are likely to find science less difficult.

5.2.5 Classroom activities

Classroom activities appear to be relatively important variables in view of the contribution made by the R^2 changes (Tables 5-1 to 5-4). More frequent collaborative activities are associated with greater enjoyment of science (Figures 5-20 & 5-21, below) and less frequent teacher directed activities are associated with less difficulty with science (Figures 5-22 & 5-23, page 318). For both of these variables the effects are more pronounced at secondary school than at primary school.

Figure 5-20: Relationship between children's enjoyment of science and the frequency of collaborative activities in year 6

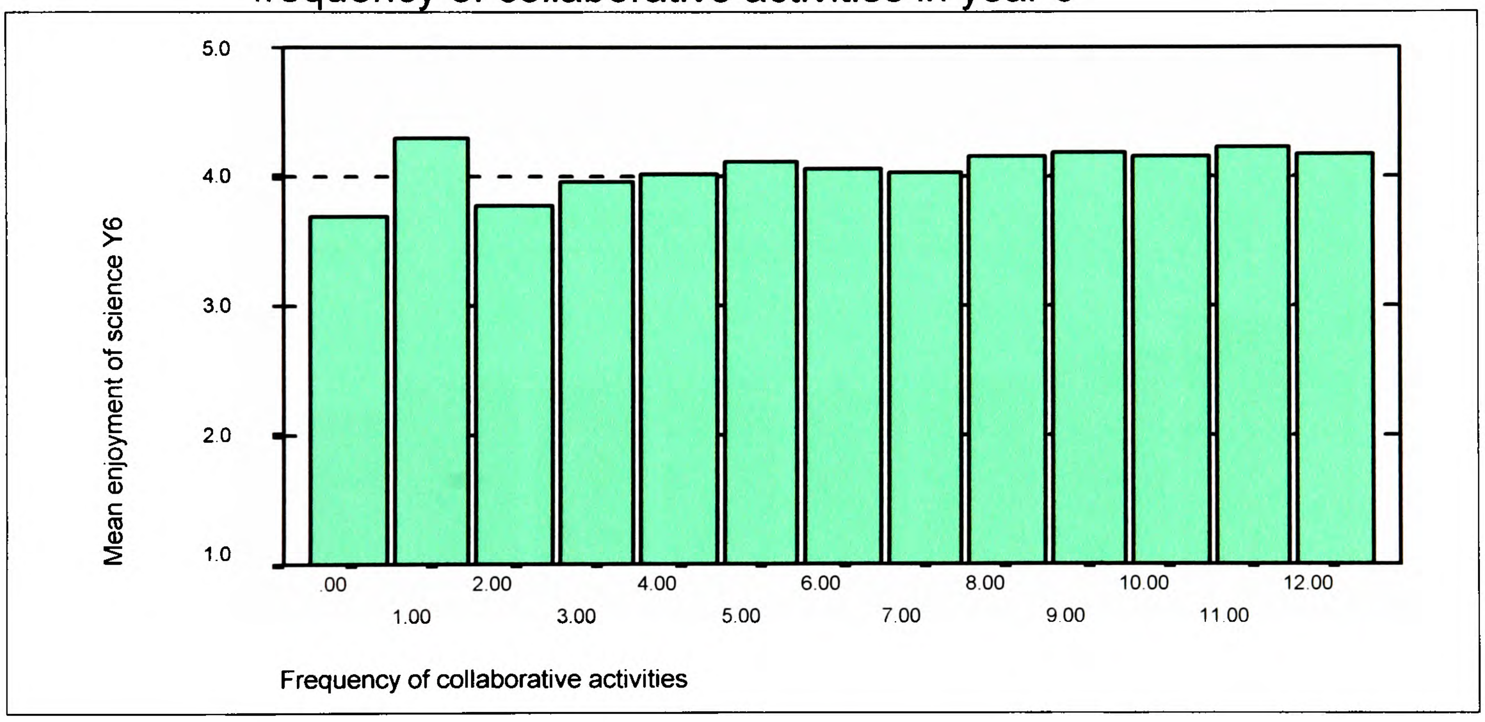


Figure 5-21: Relationship between children's enjoyment of science and the frequency of collaborative activities in year 7

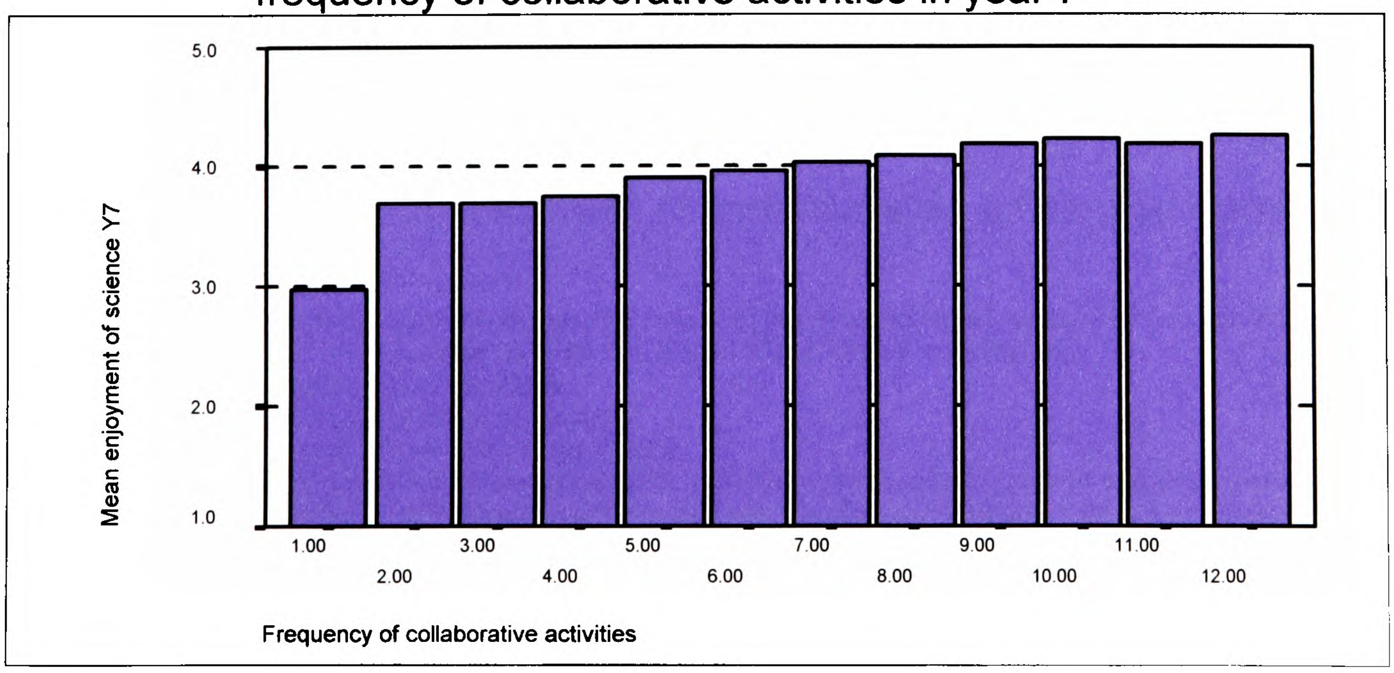


Figure 5-22: Relationship between the difficulty of science and the frequency of teacher directed activity in year 6

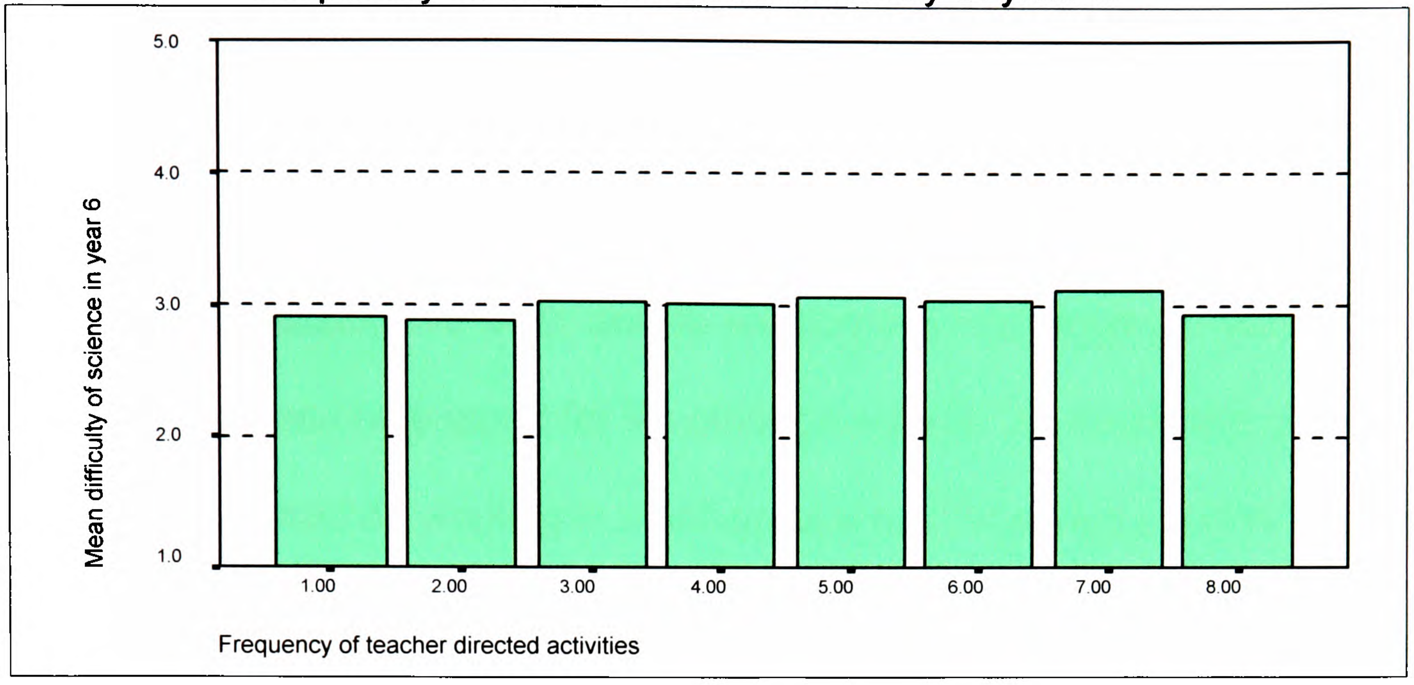
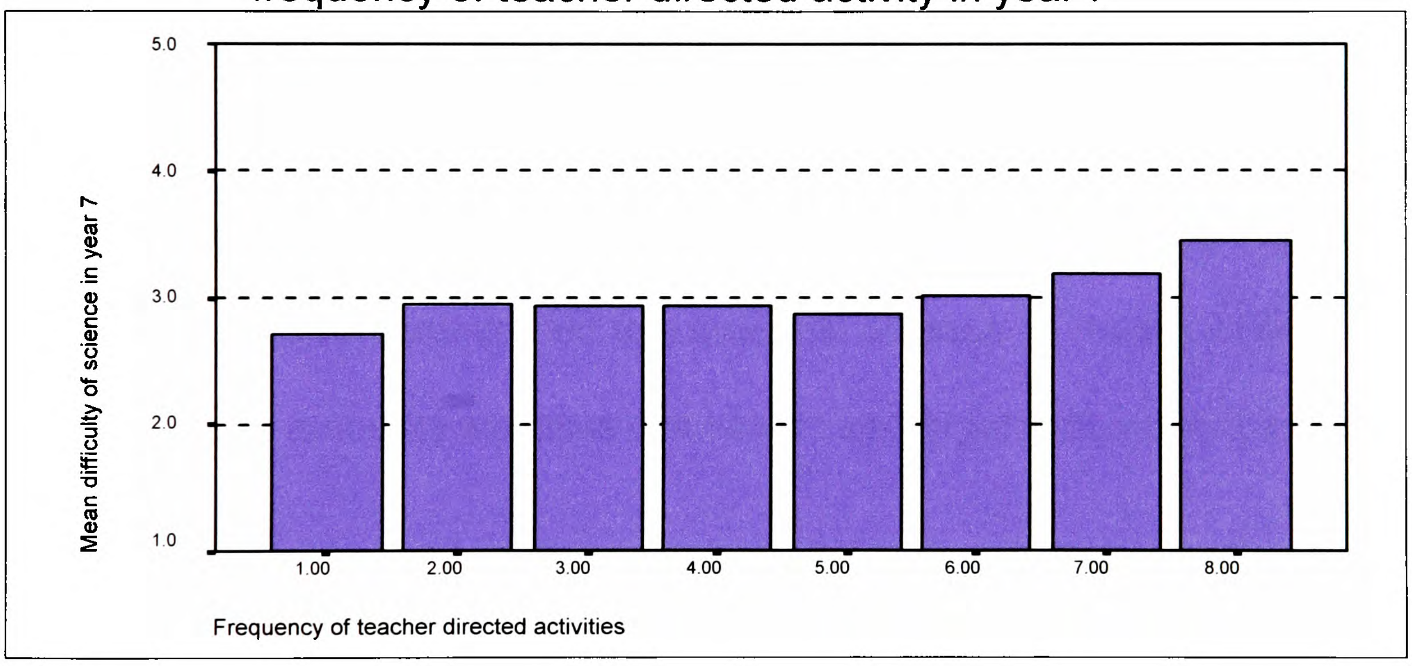


Figure 5-23: Relationship between the difficulty of science and the frequency of teacher directed activity in year 7



Collaborative working[1] is believed to improve motivation and encourage learning in science (for example, Martin Diaz & Kempa, 1990). Discussion among pupils is thought to assist the development of understanding and active learning to

[1] In discussing collaborative learning activities, the nature of the activities encompassed by this sub-scale must be borne in mind. Group work in this context refers to three items from the children's questionnaire:

1. We talk in a group about our ideas
2. We talk to the teacher about our ideas
3. We work in small groups to do experiments

Items 1 and 3 reflect the amount of co-operative work and discussion between children occurring during science lessons and item 2 reflects the amount of discussion with the teacher. The frequency tables 4.20 & 5.21 show that, on transfer, children are likely to experience fewer opportunities for discussion with each other and with teachers but more opportunities for practical work in small groups. However, the overall change will probably depend upon factors within the individual primary and secondary schools involved in the transfer.

encourage more positive attitudes. Active learning is regarded as a means of developing positive attitudes to science, and Woolnough (1994b) has emphasised the value of practical work in motivating pupils and in creating positive attitudes to science. In the present study, the frequency of small-group practical work is an element of 'collaborative work' and its relationship to changes in attitude to practical work can be seen as support for Woolnough's views. An emphasis on use of practical work and on working in small groups both at primary and at secondary school might improve attitudes to science.

The context in which the learning takes place is regarded as being very important in its affect on attitudes to science. It has been suggested (White,1993) that opportunities for discussion between children and with the teacher will affect attitudes and learning in science. White suggests that lessons using more discussion and argument or more teacher-dominated talk provide different contexts for science. Teacher-dominated talk presents science as a body of knowledge determined by authority whereas discussion and argument present science as:

> *'a set of opinions constructed from and supported by personal opinion.'*
> (Op. cit., p114).

Perhaps the use of collaborative activities is related to greater enjoyment of science lessons simply because it allows opportunities for active learning and is in itself a motivating experience. However, it is also possible that the context set by the teacher is a relevant factor, and that the teacher's personal view of science and the level of science training are important factors in determining this context. Since the year six and year seven data suggest that, on average, the frequency of use of collaborative learning falls on transfer to secondary school (Chapter 4, page 209), and Stark and Gray (1999), indicate that group work may be particularly enjoyed by boys, it might be expected that boys' attitudes to science would decline *more* than those of girls. The present study finds that overall there is more of a decline in enjoyment of science for boys than for girls.

On the other hand, the interview data from the current research indicates that, on transfer, there is a change in the composition of groups for collaborative activities; single-sex group working being more usual at secondary school, whereas at primary school mixed-sex groups, organised by the teacher are the norm. Perhaps changes in the organisation and utilisation of groups after transfer affects attitudes to science differently for boys and girls. It has been suggested that girls and boys prefer to work in single-sex groups in science lessons (Moller Anderson & Sorensen, 1995; Murphy et al, 1995), and further, that conflicts are more likely to arise in mixed-sex groups (Murphy et al, 1995; Alexopoulou & Driver, 1997; Matthews and Sweeney, 1997). Such evidence argues that *girls* should benefit from a move to single-sex, small-group activities.

The textual analysis found more comments about 'group-work' from girls than from boys (see Appendix 6) and it appeared that being allowed to work with friends was important to girls:

> ** 979 I like Miss [X] she let's us do things and we can work with our friends and sit with them (Girl)*

When it was not possible to work with friends negative feelings emerged:

- *2137 I think that science at secondary school is more different and more boring, but we didn't do a lot of science so I cannot really compare it. But I think that we should do more experiments and work with people that we get on with. (Girl)*
-

> **2131 mostly we only do text book and if we do do experiments we aren't allowed to do it with our friends. (Girl)*

While such comments do not provide conclusive evidence one way or the other, they certainly suggest that although collaborative work might be important, the composition of the group may be equally important.

Additional support for this idea comes from a comparison of the three secondary schools in the sample using single-sex teaching[1] with a similar mixed-sex comprehensive school (Table 5-9).

Table 5-9: Structural variables for four different schools in the same area

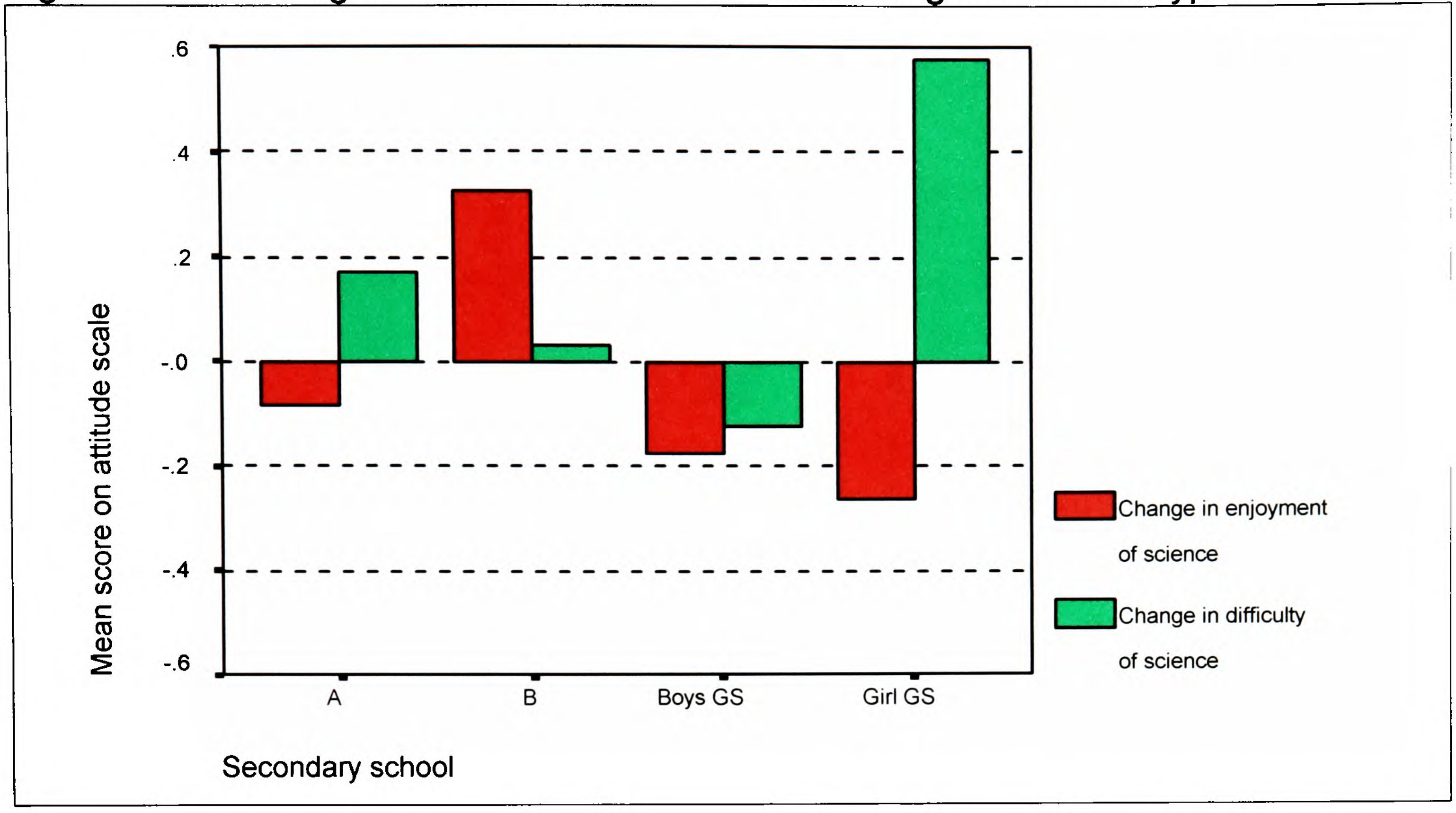
School structural variables	Comprehensive A Mixed-sex teaching	Comprehensive B Single-sex teaching	Girls Grammar School	Boys Grammar School
Roll	1447	1479	676	660
Year 7 intake	246	259	93	95
Sixth form	Yes	Yes	Yes	Yes
Free school meals %	5.46	5.34	1.33	1.67
5 or more A-C grades %	61.0	61.0	100.0	99.0
Special needs %	14.5	12.4	0.3	0.0
Statements %	0.8	1.2	0.0	0.0
Unauthorised absence %	0.1	0.1	0.0	0.0
Ability grouping	Mixed ability	Single-sex sets	Mixed ability	Mixed ability
Teaching approach	Integrated	Separate Sciences	Separate Sciences	Integrated
Scheme of work	Salters	Own	Starting Science	Starting Science

The non-selective single-sex school (B) was in the same large town and covered the same geographical area as another comprehensive school (A) that did not use single sex teaching. The two comprehensive schools were comparable, as were the two Grammar schools: they were in the same geographical area, were of similar size, with similar proportions of children with special needs, free school meals requirements, unauthorized absences and academic outcomes.

However, these schools had very different average scores on the attitudes to science questionnaire in the present study (Figure 5-24 overleaf).

[1] One boys' grammar school, one girls' grammar school and one mixed comprehensive school using single-sex teaching.

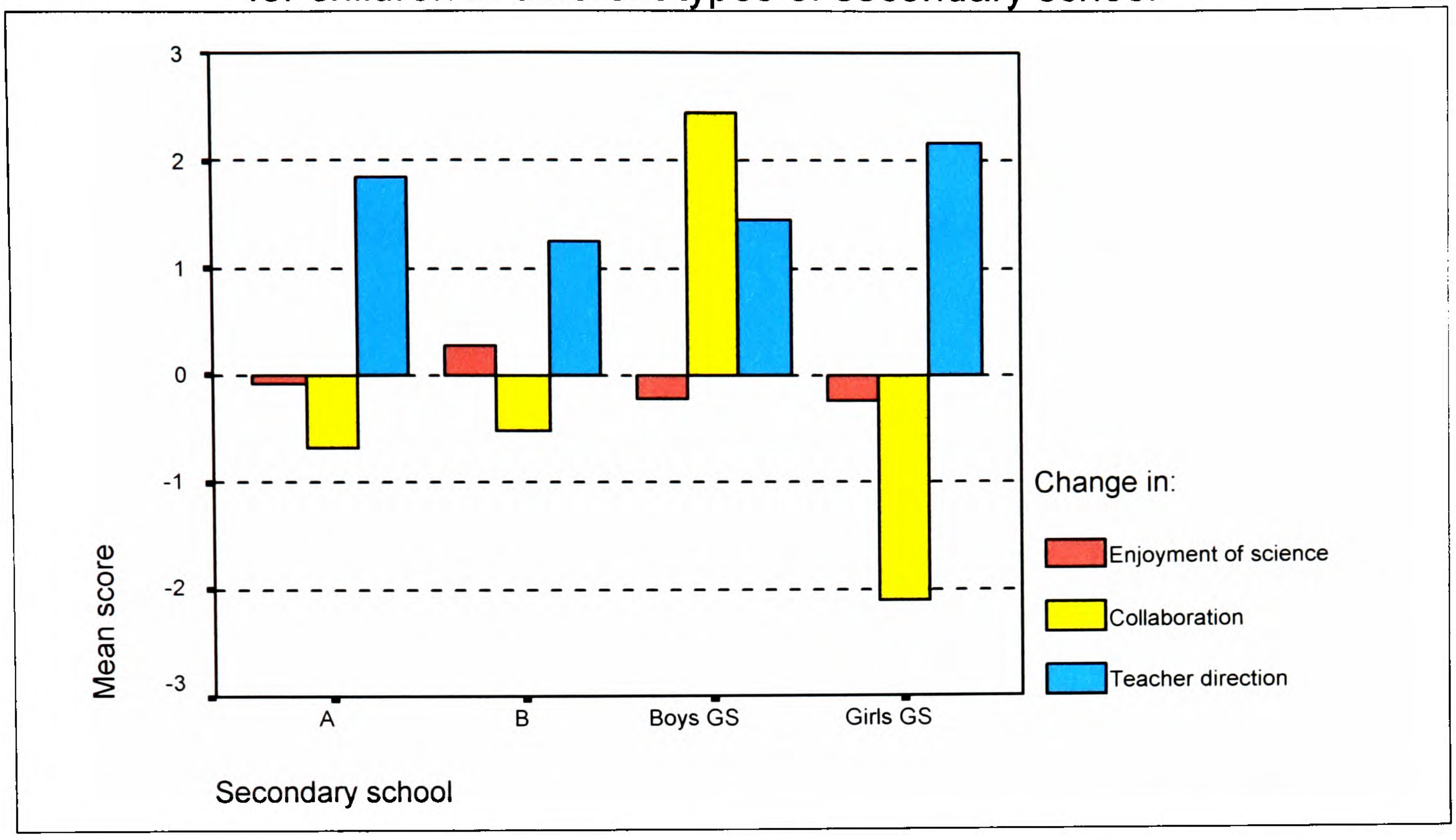
Figure 5-24: Changes in attitudes for children moving to different types of school



Enjoyment of science declined in the two Grammar schools and the mixed-sex teaching comprehensive (A), but in school B there was an increase in enjoyment. Indeed, the girls and boys in the selective schools enjoyed science *less* after transfer than those in either of the comprehensive schools. Nor can it be argued that enjoyment declined in the selective schools as a result of greater perceptions of difficulty, since in the boys Grammar school there was a decrease in the perception of difficulty and in the girls Grammar school, the increased perception of difficulty was highest.

The changes in frequency of classroom activities on transfer are compared for the four schools in Figure 5-25 overleaf.

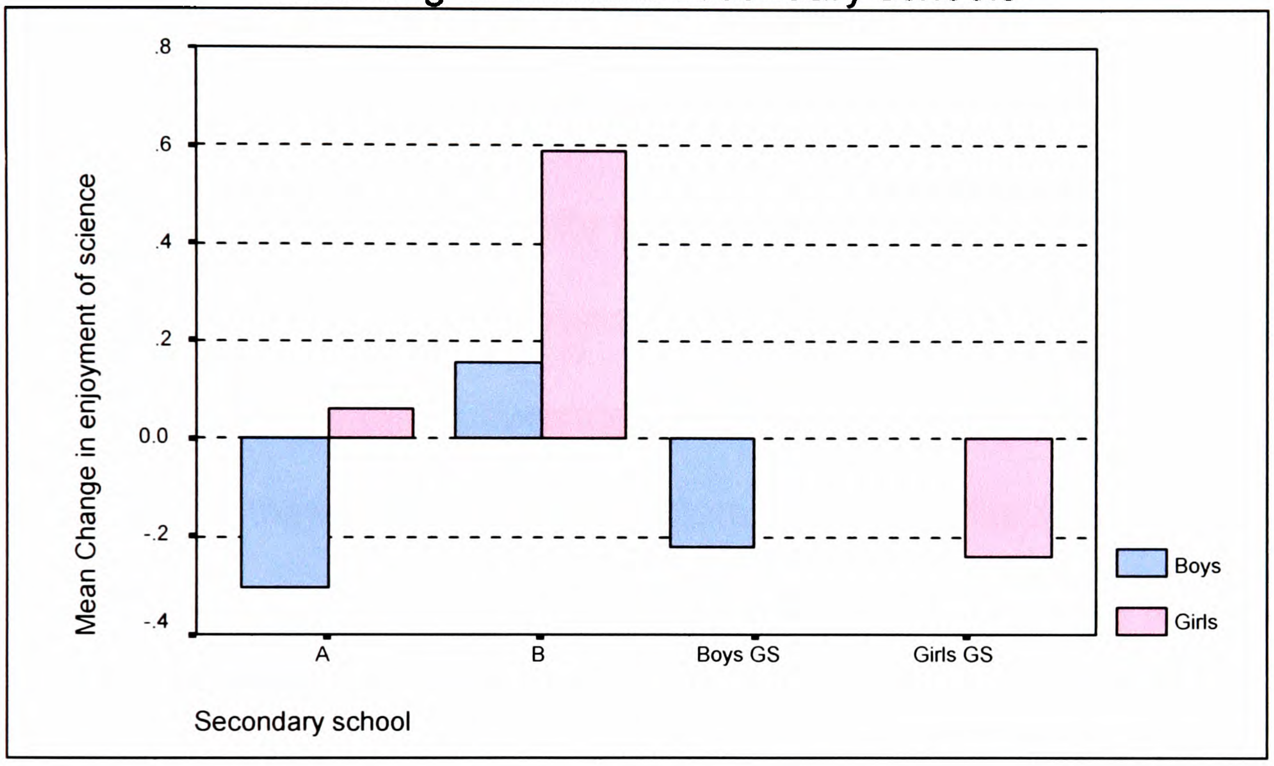
Figure 5-25: Average changes in the frequency of classroom activities for children in different types of secondary school



In school A children work in mixed-sex groups, but in the other schools the groups are single-sex for all activities. School B has a smaller increase in the amount of teacher directed learning and a smaller decrease in the amount of collaborative learning than school A, so pupils on transfer to school B should experience less change in classroom activities than those moving to school A, and the average enjoyment of science is higher in school B.

Collaborative activity is highest in the boys Grammar school, but there is also a lot of teacher direction. The girls Grammar school, where enjoyment of science declined most, had the greatest amount of teacher direction and the smallest amount of collaborative working. So, although the girls in the selective school are working in single sex groups, they seem to have less opportunity to work in this way than the girls in either schools A or B, and the enjoyment of science has fallen the most in the girls Grammar school. These observations suggest that collaborative activities are important, and that perhaps single-sex working could give some advantage. This argument rather neglects the apparent anomaly of the boys' Grammar school, where enjoyment declines despite an average increase in collaborative work. A possible explanation, and an important difference between boys and girls, emerges when changes in enjoyment are categorised by gender (Figure 5-26). It may be that single-sex schools do not have the same effect on both sexes.

Figure 5-26: Average change in enjoyment of science, by gender, on moving to different secondary schools



Boys' enjoyment of science declines in both school A and in the all-boys school, and only increases in school B. But even in school B the change in their enjoyment of science does not match that of the girls. It seems possible that single-sex teaching in comprehensive schools makes a positive difference, and in particular for girls. Clearly other factors are likely to be involved, and the most noteworthy seems to be the change in their teachers' views of science; the teachers at the boys' Grammar school had considerably higher scores for the 'importance of science as a body of knowledge' scale than teachers in the other schools discussed here.

To return to the original point, where like is compared with like, for children in the single-sex school there is a rise in enjoyment of science but for those in mixed-sex schools there is a fall. It is suggested that change in the amount of collaborative learning activity and in the composition of groups for such activity has an important part to play in children's perceptions of science lessons. Girls', in particular, may benefit from working collaboratively in single-sex groups.

The literature has suggested that gender is 'probably the single most important variable related to pupils' attitudes to science' Gardner (1975). In the discussion in Section 5.2.1 (pages 290-297) it was argued that the differences between boys' and girls' attitude to science is small and depends upon specific issues. In the research literature these specific issues, the teaching approaches used and the classroom environment, are mentioned as having particular significance for gender differences. But the literature also gives grounds for thinking that these are important factors affecting attitudes to science in general. The question is, does the use of a particular scheme of work and teaching approach diminish existing gender differences or, do particular approaches give rise to gender differences? For this sample of children attitudes to science do not seem particularly dependent upon gender, once other variables are controlled. However, the activities and approaches used in science lessons, and attitudes to school emerge as important related issues. Much of the earlier research into attitudes to science has lacked control of other variables, particularly of attitudes to school, and the apparent gender differences observed must therefore be questioned. The discussion of the longitudinal analysis in Appendix 9 returns to this issue.

5.2.6 SCHOOL ATTITUDES AND SCHOOL STRUCTURAL VARIABLES

So much of the variation in science attitudes is related to school attitudes that an examination of the factors specifically related to school attitudes is warranted. But since attitudes to school were included only as a control for attitudes to science, the majority of the variables collected for this research were specifically related to science rather than to school. However, all non-science variables were included in linear regression analyses with enjoyment of school in years 6 and 7 as the dependent variables (Tables 5-10 and 5-11). It is arguable whether CASE should have been included in the analysis since it could be regarded as a science variable. Although CASE was used as enrichment within the science curriculum it is believed to have educational effects across the whole curriculum (for example, Shayer, 1999) and so was included as a potentially non-science variable.

The regression analyses indicate that attitudes towards school in year 6 are significantly related to gender, ethnic origins and the teaching approach used by the primary school (Table 5-10). However, the percentage of the variance explained by the selected variables is very low, for both the year 6 and 7 analyses, indicating that there are other important factors not included in these analyses.

Table 5-10: Significant variables for enjoyment of school in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.17
Child	Gender	0.028	0.028	0.26
	Asian	0.030	0.002	0.35
School	Use of topic approach in primary school	0.033	0.004	0.10

Girls and children of Asian origin were more likely to enjoy school than boys and children from other ethnic backgrounds (Figures 5-27 and 5-28 overleaf).

Figure 5-27: Attitudes to school of boys and girls in year 6

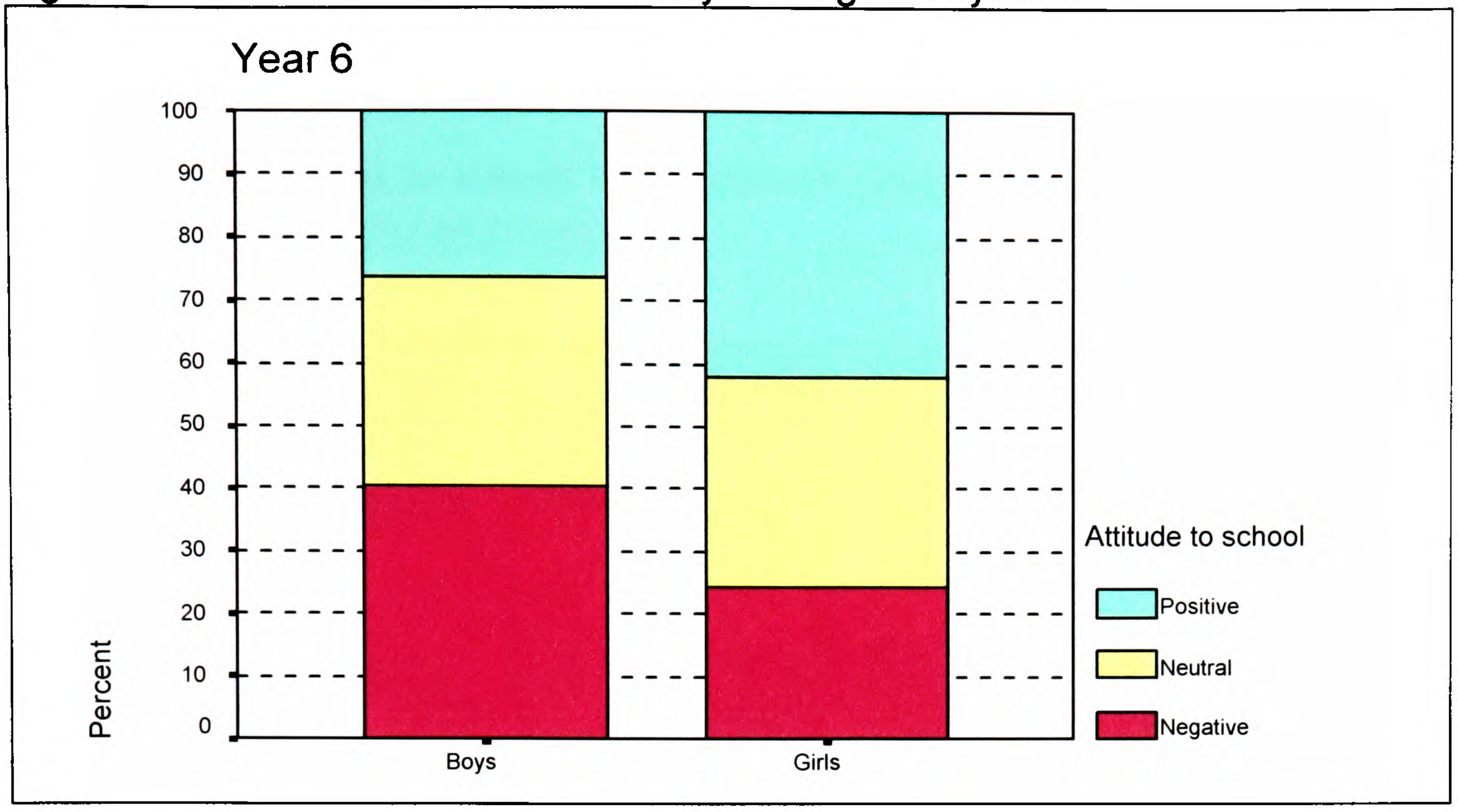
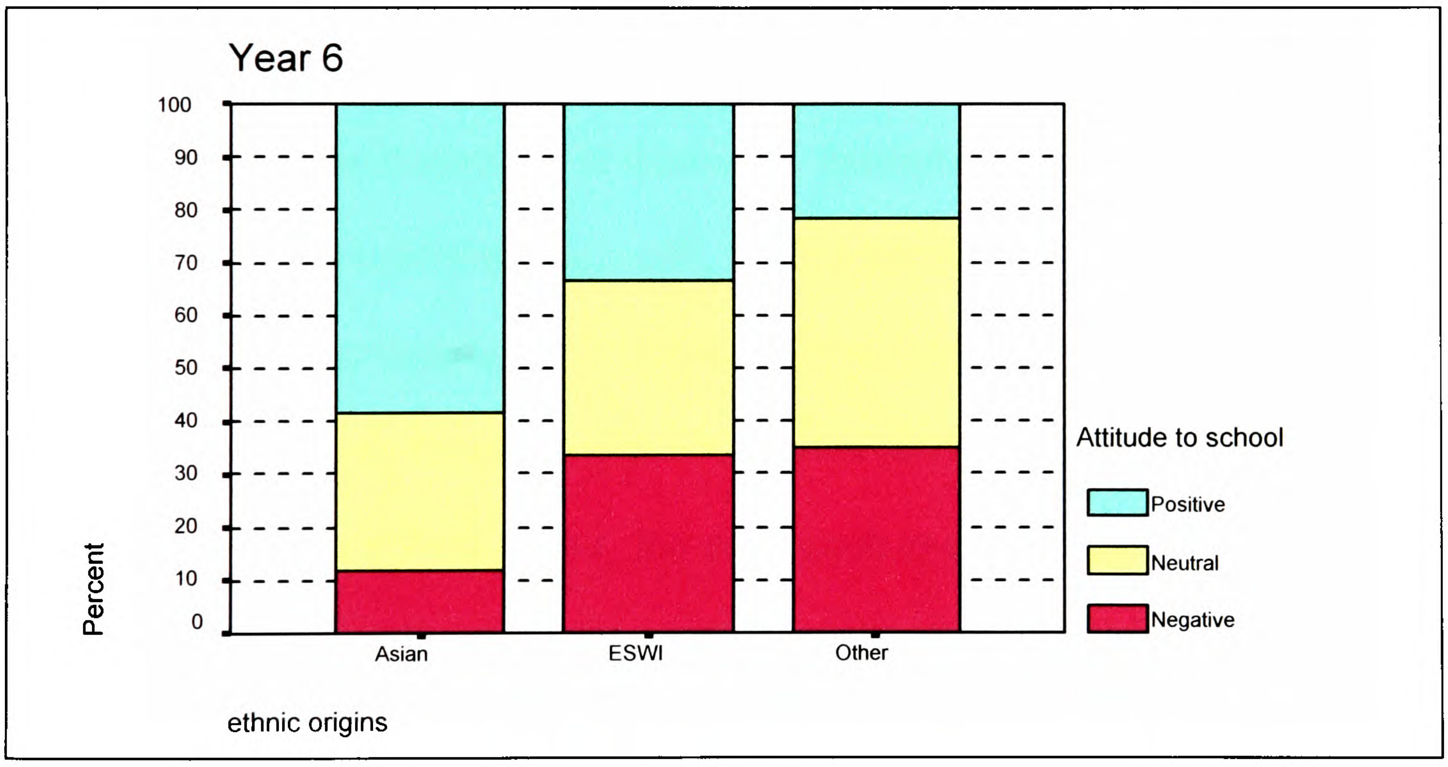


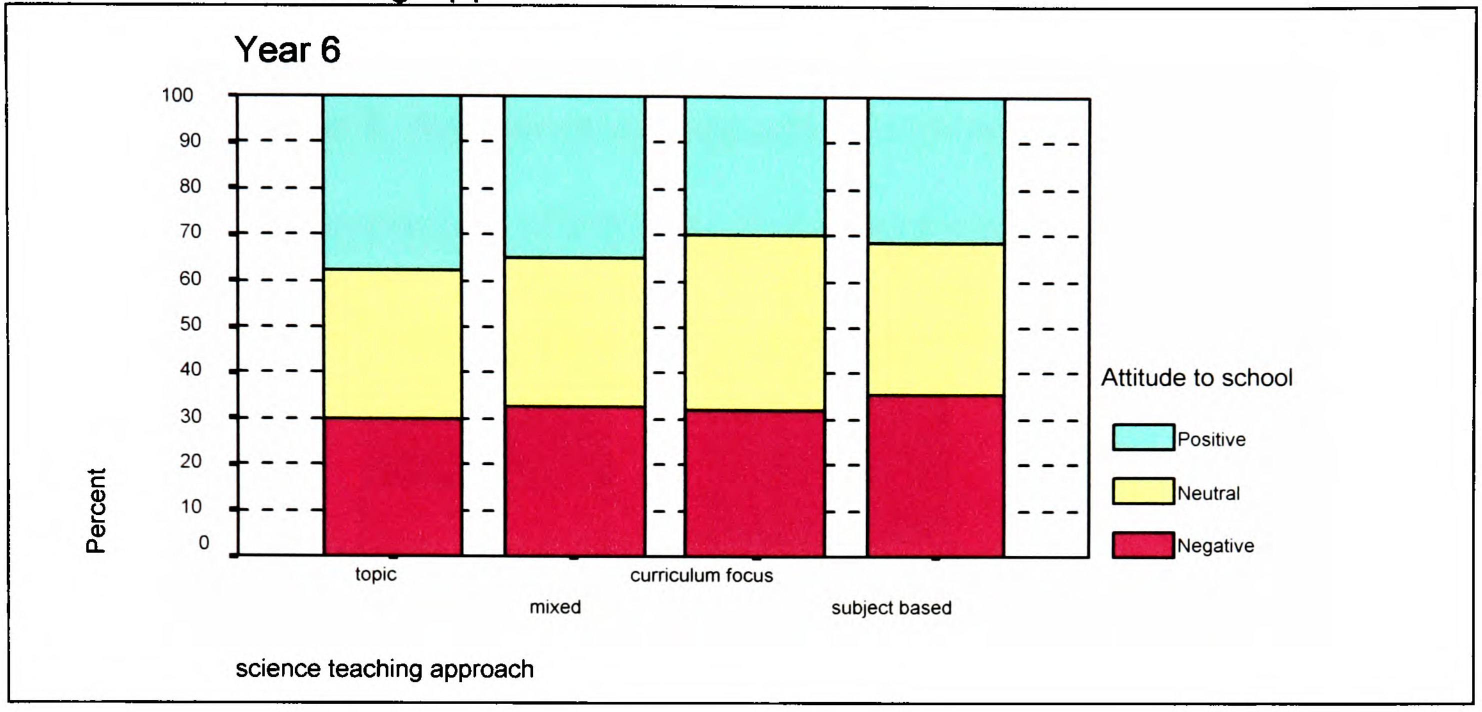
Figure 5-28: Attitude to school for children in year 6, by ethnic origin.



These findings are supported by the literature, which indicates that girls are likely to be more positive about school than boys (Spelman, 1979; Barber, 1994; Keys, Harris & Fernandes, 1995) and that children from minority groups may have more positive attitudes than the majority culture (Blatchford, 1996; West et al, 1997). However, the small number of ethnic minority children in the whole sample means that the numbers were too small to give any reliable results (see Appendix 4).

The use of the Topic approach was associated with greater enjoyment of school for most children (Figure 5-29).

Figure 5-29: Attitude to school for children in year 6 experiencing different teaching approaches



The relationship between the teaching approach and enjoyment of school may be more complex than it appears at first sight. School size may be an important factor in determining the teaching approach, for this sample of schools, smaller schools were more likely to use the topic approach and large schools to use a subject approach. Since smaller primary schools were also associated with lower proportions of free school meals, the difference in enjoyment of school could be linked with the type of approach, or with the different backgrounds of the children.

The regression analysis with enjoyment of school in year 7 as the dependent variable shows that gender, examination success in the school and the use of the CASE scheme are significant factors (see Table 5-11, below).

Table 5-11: Significant variables for enjoyment of school in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 0.97
Child	Gender	0.023	0.023	0.26
School	% with 5 or more A-G grades	0.042	0.019	0.02
	Use of CASE scheme	0.048	0.006	-0.20

As in year 6, girls appear to enjoy school more than boys and enjoyment is generally higher in schools achieving greater success in GCSE examinations. However, in schools using the CASE scheme attitudes to school are less positive. **Figure** 5-30 compares attitudes to school for girls and boys in year 7 and, as discussed for year 6, the literature supports this finding.

Figure 5-30: A comparison of attitudes to school for boys and girls in year 7.

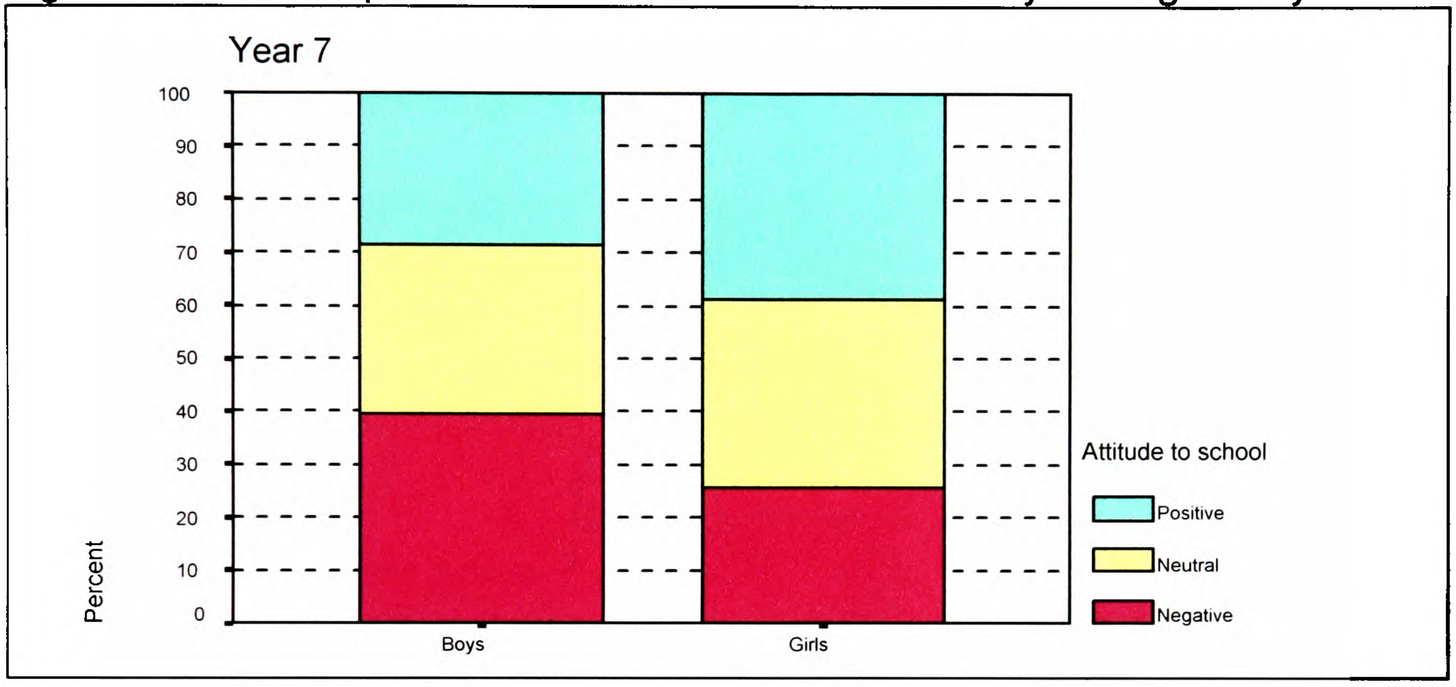
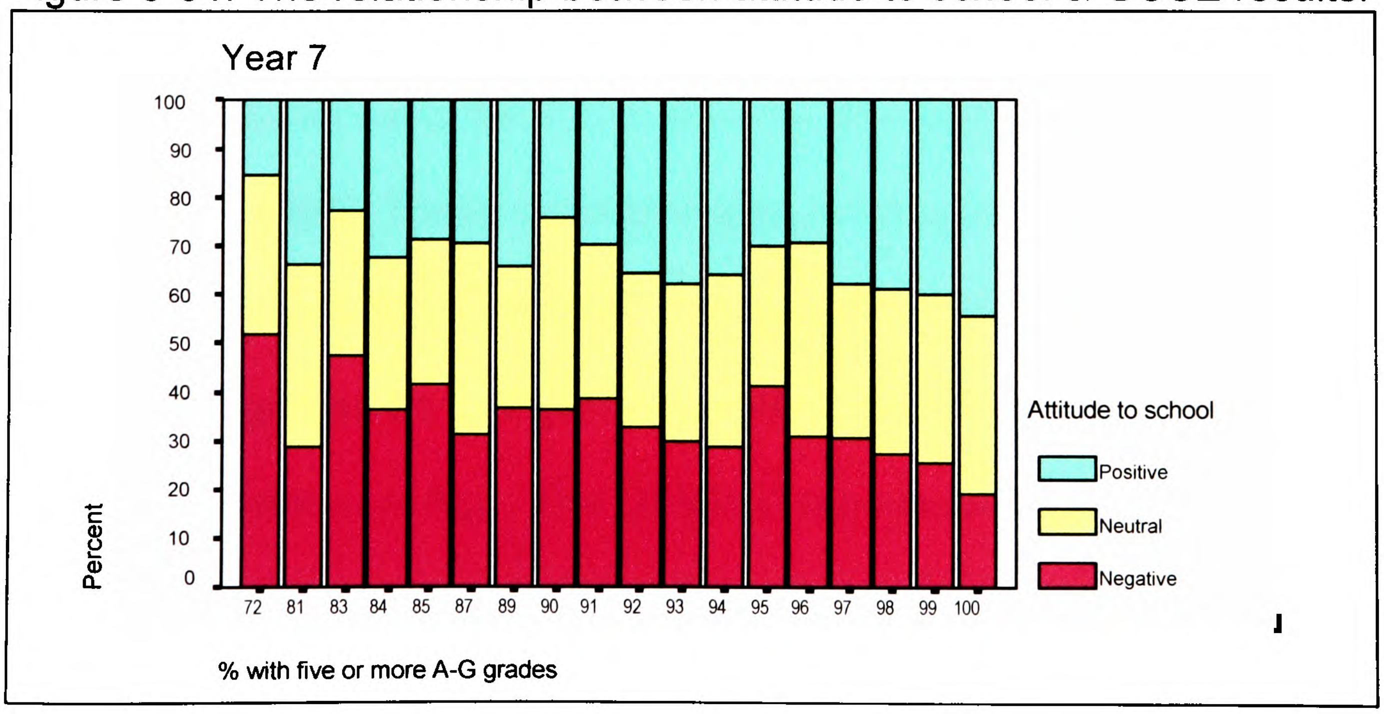


Figure 5-31, below, shows the relationship between a school's academic success, based on the percentage of A-C grades gained in the school at GCSE, and pupils' attitude to school. This indicates that children in more successful secondary schools are likely to have more positive attitudes to school.

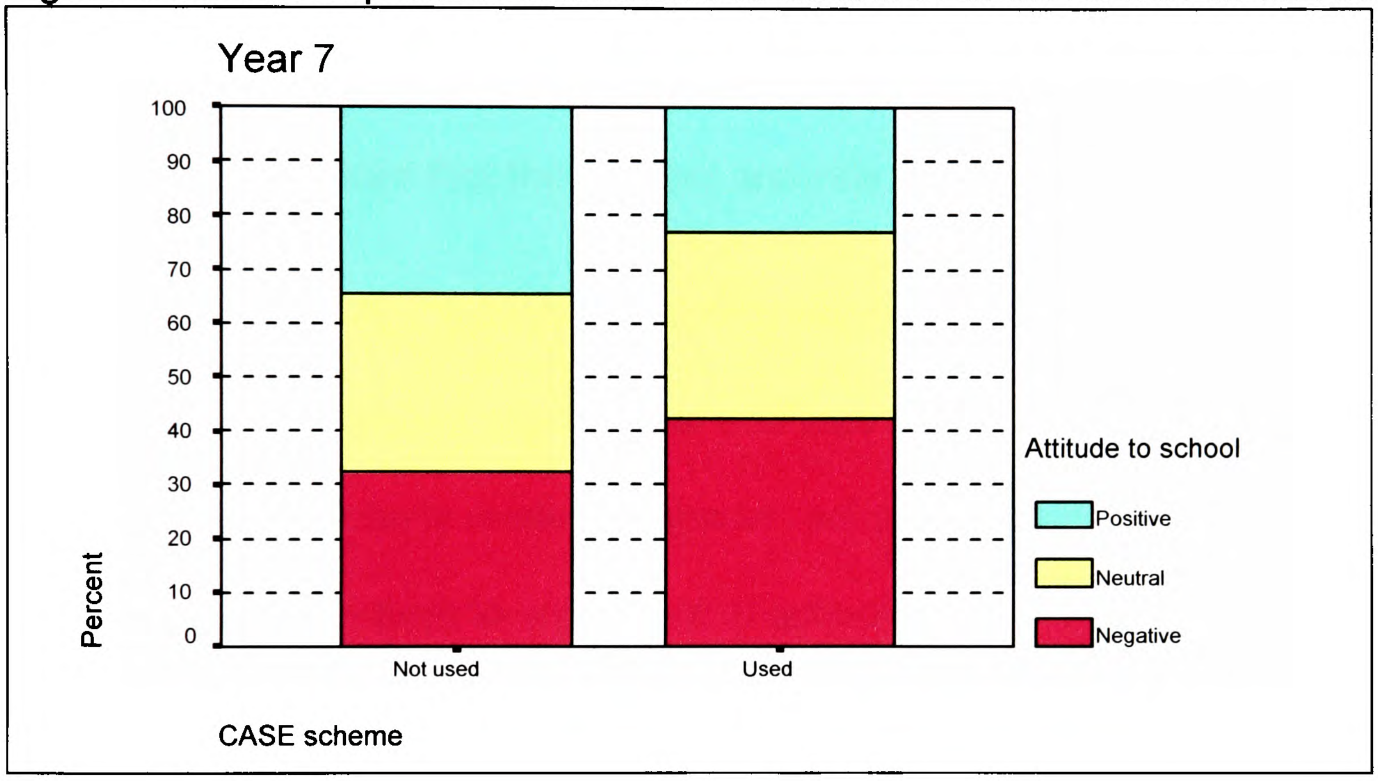
Figure 5-31: The relationship between attitude to school & GCSE results.



Since school examination results are significantly associated with socio-economic indicators (page 223), it is likely that the socio-economic background of the school is related to children's attitudes to school, as suggested by Barker Lunn (1971) and Sammons and Mortimore (1990).

Children in CASE schools are likely to have less positive attitudes to school than those in schools where the CASE scheme is not used (Figure 5-32).

Figure 5-32: A comparison of attitudes to school in CASE & non-CASE schools.



The appearance of the CASE scheme as a factor associated with attitudes to school is intriguing. The relationship between general enjoyment of school and the school's use of the CASE scheme suggests that there may be something different about the schools using the CASE scheme; this has also been referred to by McClennan (2000). These schools tended to have (on average) higher FSM and an intake of pupils with lower CAT scores (page 296), but these differences alone cannot be regarded as sufficient explanation since in some schools FSM was low and CAT scores were high. The OFSTED reports for these schools suggest that they may have all been under some pressure to 'improve'; perhaps the CASE scheme has been introduced into schools where OFSTED has identified a need for improvement, and this may account for these schools being 'different'.

In summary, only a small amount of the variation in attitudes to school can be explained using the variables measured in the current research. However, the important factors seem to be directly or indirectly related to gender and to social class and these findings are supported by other research. Finally, since the literature indicates that school attitude is related to factors not dealt with in this study, it is recognised that the present analysis is limited.

5.2.7 ATTITUDES TOWARDS THE USE OF COMPUTERS IN SCIENCE

The regression analyses indicate that attitudes towards the use of computers in science are significantly related to gender, school variables and classroom activities, and also to some extent to enjoyment of school (Tables 5-12 & 5-13). However, the percentage of the variance explained by the selected variables is quite low, only 9% at primary school and even less, 6% at secondary school.

This suggests that there may be factors outside school that have important effects on attitudes towards the use of computers. Both year 6 roll and free school meals in year 6 could be regarded as indicators of the socio-economic environment of the school, and these are both significant factors in attitudes towards the use of computers in science in year 6; contributing substantially to the total R^2 change as well as having relatively large B values.

Table 5-12: Significant variables for attitudes to computers in science in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.10
Child	Gender	.019	0.0193	-.26
School	Free school meals %	.044	0.0247	.01
	Year 6 roll	.048	0.0037	.00
Classroom activities	Teacher directed activities	.070	0.0222	.07
	Standardised activities	.074	0.0043	.03
Attitudes to school	Enjoyment of schoolwork	.082	0.0084	.17
	Enjoyment of school	.086	0.0036	-.08

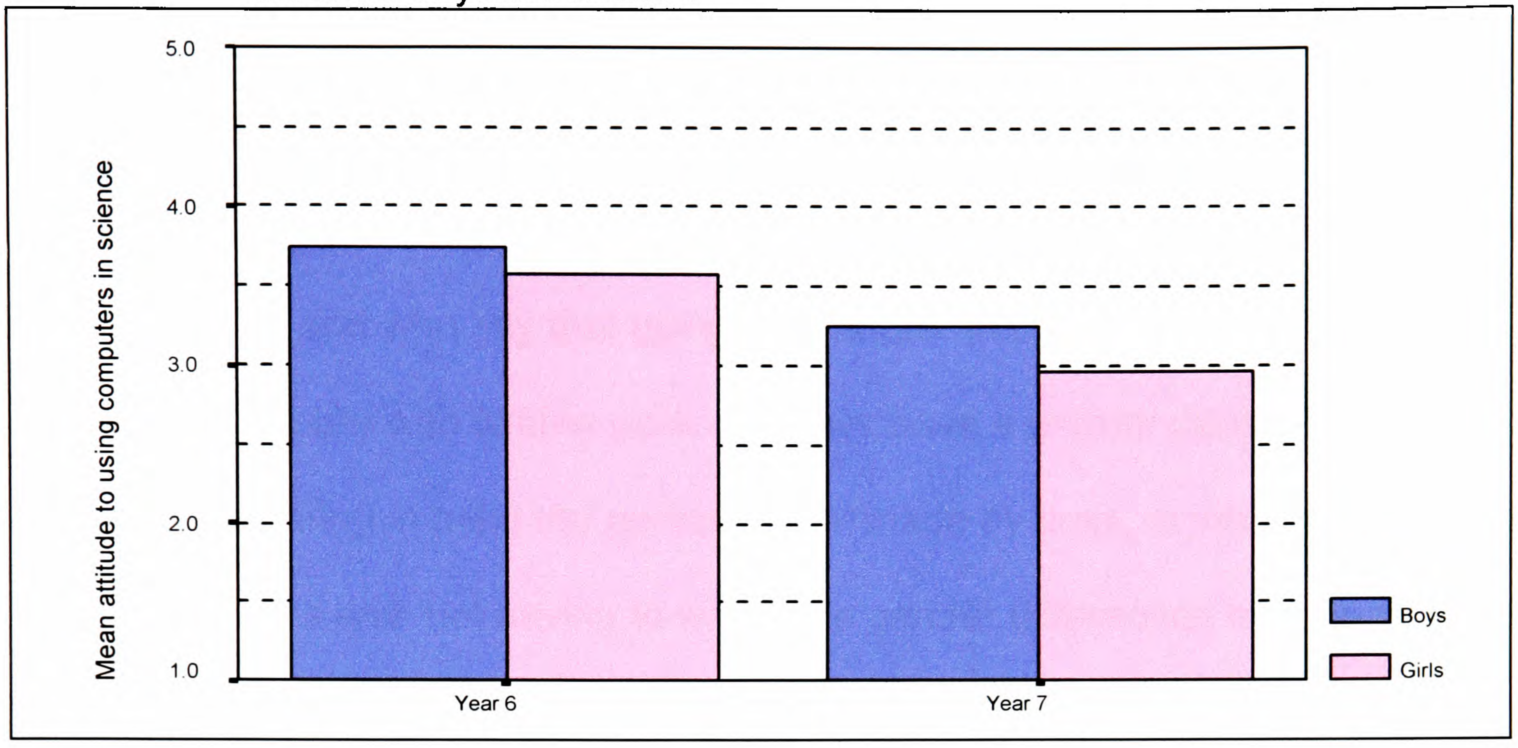
Table 5-13: Significant variables for attitudes to computers in science in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.40
Child	Gender	.013	0.0128	-.19
School	Use of CASE scheme	.030	0.0175	.34
Classroom activities	Standardised activities	.049	0.0187	.07
Attitudes to school	Enjoyment of school in year 7	.060	0.0135	-.13

There are also some obvious differences between the results of regression analyses for attitudes to computers in science and those for other 'science attitudes' (i.e. enjoyment of science, difficulty of science and difficulty of science writing, p.287-288). First, the amount of variance explained by school enjoyment is considerably smaller for attitudes towards the use of computers in science; this finding suggests that the use of computers is not perceived as a particularly school related activity. Second, no teacher variables contribute to this variance, indicating that the experiences and views of teachers may not be relevant to children's attitudes to computers in science.

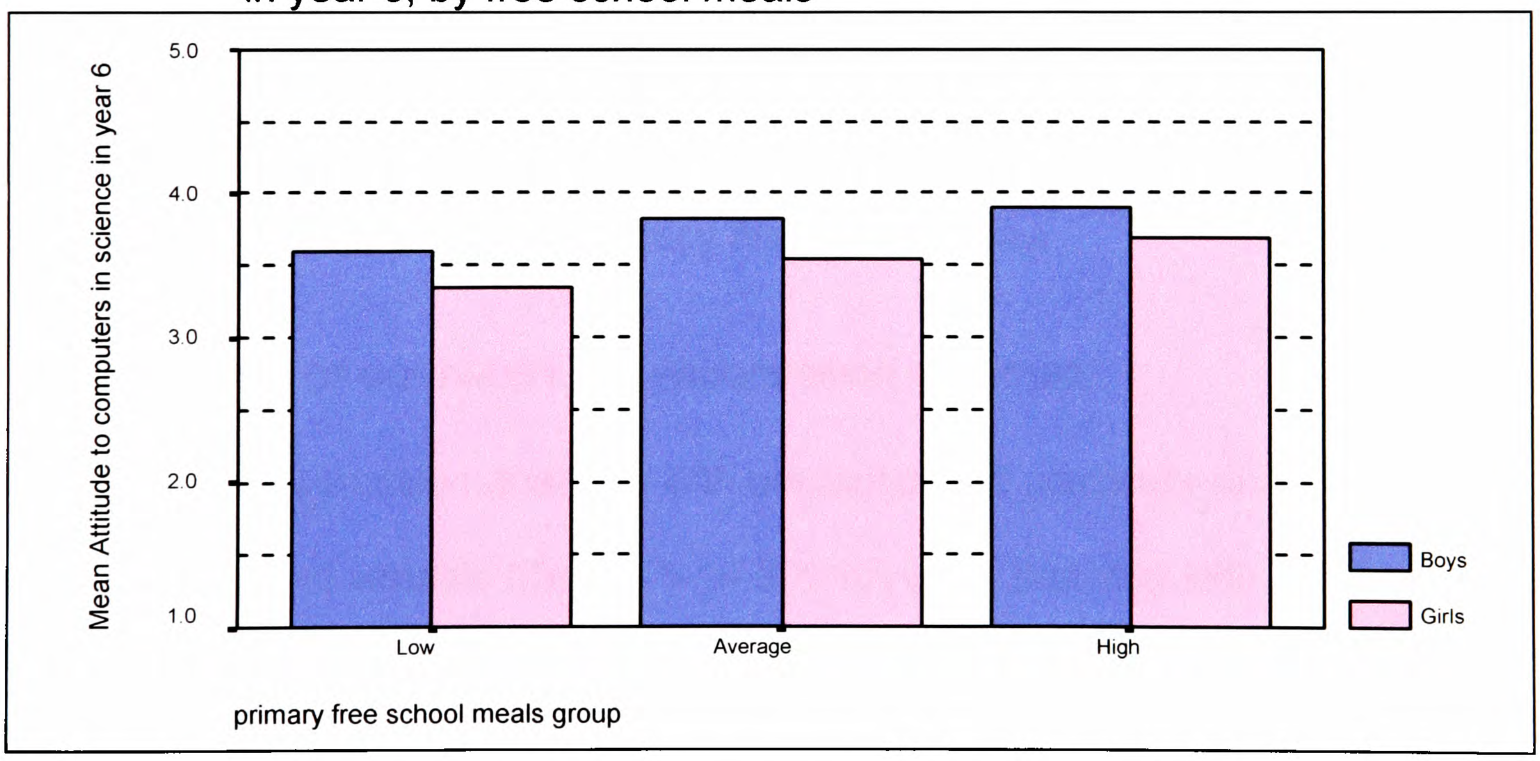
There are unambiguous differences between boys' and girls' attitudes to using computers in science; boys are more positive in both years 6 and 7 (Figure 5-33).

Figure 5-33: Gender differences in attitudes to the use of computers in science in years 6 and 7



Furthermore children from schools with a high proportion of free school meals have more positive attitudes than those in school in more affluent areas (Figure 5-34).

Figure 5-34: Gender differences in attitudes to the use of computers in science in year 6, by free school meals



Although not included in the 'attitude structure', it is informative to look at the relationship between attitudes to written work and to computer use in science (see Table 4-5 on page 214 & 4-6 on page 216). There is a significant *negative* relationship between the difficulties connected with science written work and the use of computers. Children who *enjoy* science, who do *not* find science difficult and who are *not* experiencing difficulties with science written work are *unlikely* to express positive views about the use of computers in science. In contrast, those children who find science difficult are those who more often express the wish to use computers and who say that using a computer makes science easier. Boys have more difficulty with written work and boys have a greater desire to use computers. Bearing in mind the particular link made by boys, in interview, between using computers and 'not having to write', the gender differences may be related to writing difficulties rather than to science attitudes.

The proportion of free school meals in the school is one of the most important variables associated with the variation in attitudes to computers. This suggests that attitudes to using computers are strongly related to the general level of deprivation in the area. Since there are links between deprivation and levels of literacy (Demack, Drew & Grimsley, 1998), perhaps computer use may be related to writing skills. Hence, the gender differences observed for computer use probably have more to do with literacy than with science.

5.2.8 PERCEPTIONS OF CONTINUITY AND PROGRESSION IN SCIENCE

The results of regression analyses with perceptions of continuity and progression as the dependent variable (Tables 5-14 & 5-15) show that very little of the variance is explained by the predictor variables that were included. The only significant factors that explain more than 1% of the variance (R^2 > 0.01) are the frequency of teacher directed activities at primary school and the use of transfer information at secondary school. The emergence of these two variables as significant indicates that the nature of the classroom activities and the use of transfer information may be particularly important for the child's view of continuity and progression.

Table 5-14: Significant variables for perceptions of progression and continuity in science in year 6

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 4.32
Teacher	Average score on final ID scale		0.0052	-.09
	Length of teaching employment	.005	0.0055	-.04
Classroom activities	Teacher directed activities	.011	0.0117	-.03
	Standardised activities	.022	0.0071	-.02
	Student directed activities	.029	0.0036	-.02

Table 5-15: Significant variables for perceptions of progression and continuity in science in year 7

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 3.79
School	Teacher assessments used	.017	0.0169	-.19
Classroom activities	Student directed activities	.028	0.0107	-.05

These results indicate that the variables chosen for this study probably have little bearing on children's views of continuity and progression. However, the children's written response data give a clearer picture of their views on the changes in progression and continuity and these are discussed in Chapter 6 (page 374).

5.3 Summary

Boys are more positive about science than girls in year 6, but in year 7 the attitudes of girls to science in this study appear to be more positive than is suggested by the research literature. The introduction of a primary science curriculum may have increased positive attitudes toward science among girls; but it is likely that the type of analysis, controlling for other variables, and particularly attitudes to school, has produced this observation, which is rather different from that of the research literature.

Certain school factors seem to be important: children in smaller primary schools are likely to have more positive attitudes to science, and children in secondary schools gaining higher proportions of GCSE passes are less likely to feel that science is difficult. Both of these school variables have associations with areas of higher social status, and suggest that socio-economic background may be an important variable affecting attitudes to science.

At secondary schools the use of the CASE scheme appears to be significantly linked with all three science attitudes: children using the CASE scheme seem less likely to enjoy science, and more likely to find science and science written work difficult. This finding may result from differences in the socio-economic context of the schools choosing to use the CASE scheme, gender and socio-economic stereotypes, the effects of using collaborative work without careful organisation of the groups, or incomplete transfer of CASE training to the teachers involved.

It is possible that differences in teachers' approaches to science teaching affect children's attitudes to science. At primary school, children whose teachers feel that it is important to take a knowledge-based approach enjoy science more. However at secondary school enjoyment of science is linked with the teacher's score on the child-centred factor. The indications are that children enjoy science more with teachers who combine the predominant styles of both the primary and secondary sectors. The combined effects of teachers' views and their teaching experience appear to be more important than teachers' science qualifications. Classroom activities also appear to be important; in particular the use of collaborative work is linked with more positive attitudes to science. However, it is suggested that the composition and organisation of groups needs to be carefully controlled to ensure that all children benefit from collaborative activities. Attitudes to school are very influential and regression analyses indicate that attitudes to school are likely to be affected by the socio-economic background of the school and the gender of the pupils. This finding suggests a link between attitudes to science, gender and socio-economic factors.

Attitudes to computers in science do not appear to be linked directly with those for other 'science attitudes', and the significant factors indicated by the regression analyses are also different. The proportion of free school meals in the school is one of the most important variables associated with the variation in attitudes to computers, suggesting that children from more deprived backgrounds might benefit most, in terms of development of positive attitudes, from increased use of computers in science lessons.

Children's perceptions of continuity and progression are not significantly related to most of the variables included in this study, but it is suggested that the type of classroom activities and the use of transfer information may affect children's views of continuity and progression.

CHAPTER 6. FREE-RESPONSE DATA FROM YEARS 6 AND 7

6.1 Initial analysis

As shown in Appendix 3, the free-response section consisted of an A4 page, the last page of the survey, which was left blank apart from an invitation to children to make written comments, as below:

At primary school:

Think about what it will be like to do science next year in secondary school. Make a list of any things you think will be different about science next year.

At secondary school:

How do you feel about science this year compared to last year? What things are the same and what things are different?

The responses from children, who were involved in both primary and secondary surveys, were transcribed and carefully read through many times to allow familiarisation with the general nature of the responses. The children's responses varied considerably in style and length. Some children, at both primary and secondary school, simply listed a few words. For example[1]:

At primary school:

**2060[2] Harder*	*more work*	*wires (electric)*
Homework	*potions*	*Fire (Boy)*

At secondary school:

**3000 Experiments, tests. (Girl)*

Other children wrote very brief comments, but most children set out sentences expressing their views. Most of the shorter sentences expressed straightforward

[1] All spellings and grammar in quotations are the children's own.
[2] The number preceding this and subsequent quotations, is the pupil reference number.

opinions and comparisons. However, where children wrote at some length to express their views, sentences varied considerably in structure and often included reasons for particular opinions expressed. Two typical examples are given below.

At primary school:

> *227 *We will do more dangerous experiments. The science we do will be more complicated and hard. We will do science more often, we will do it with other teachers, we will use computers more often. It will be more fun and more exciting. (Girl)*

At secondary school:

> *3018 Science this year is quite different from primary school because it doesn't join up with every other topic, because at primary school we were given a topic and we done english, science, art and other subjects around that topic. At my primary school experiments in **science** were long term and lasted at least a day. We did have some **animals** in our class room at primary school like hamsters, gerbils, fish and other creatures we could study. The write ups on experiments are basicly the same, but the experiments now are more fun and interesting. Over all I think that science is better at senior school and I wish it could of been like this at primary school. (Girl)*

Although children used very different styles, their responses reflected their subjective perceptions of school science. Previous analyses of transcripts have generally involved the coding of whole sentences and phrases and the linking of themes and ideas within the text, but in this study such searches would have excluded many children who simply gave lists of words or used very brief sentences. So, this analysis has focused on the individual words being used. The assumptions made in this analysis were:

- Individual words have meaning for the respondent.
- Words are written down because they are important to the respondent.
- Words are linked with the respondent's perceptions of school science.

The choice of individual words to be searched for came from two directions: from theory (both previous theories in the literature and theory emerging from the present quantitative study), and from readings of the text.

The transcribed texts were coded and organised with the help of QSR NUD*IST software. Word searches were then made for combinations of words or phrases with a common meaning, for example, in a search for the expression of positive feelings the following were searched for;

Good, enjoy, like, fun, brill, great, cool, wicked, exciting, interest(ing), look(ing) forward to,

Words were found using the 'pattern' search in NUD*IST. This allows similar words, different spellings and parts of words to be searched for in the text. Only the first occurrence of a word or part-word in each response was counted for each pupil. Fuller itemisation of the search words is given in Appendix 6.

It was made clear to the teachers who administered the questionnaire that there was no necessity to complete this section and that if time did not permit, then it could be omitted. Not all children made a written response (see Table 6-1 below, for details of written response rates), and it was clear from the pattern of written responses that, in some cases, whole classes had not made any. No written responses were obtained from nine classes in seven primary schools and from two classes in one secondary school, suggesting that in these classes the teacher had not felt able to allow additional time for this final section. In the remaining 157 classes at primary and 193 classes at secondary school some children had responded and others had not, suggesting that lack of response was not because of action on the part of the teacher.

Table 6-1: Response rate for free-response section of survey.

	Primary		Secondary	
	n	%	n	%
Total written responses	1730	76.62	1583	70.11
Total involved in longitudinal study	2258	100	2258	100

In classes where only some of the children had not made a written response there seem to be two possible reasons for this: firstly, that insufficient time was available (for example, for slow writers), and secondly that some individual respondents did not wish to make a written response. Although it is not possible from this study to distinguish clearly between these groups, it is possible to gain some clues about who did or did not respond and about groups who produced the larger proportions of written responses and the greater amounts of writing.

First a comparison of the proportions of those who did and did not make a written response can be grouped by gender and school sector (Table 6-2).

Table 6-2: Proportions of responses by boys & girls at primary & secondary school

	Primary Girls		Primary Boys		Secondary Girls		Secondary Boys	
	n	%	n	%	n	%	n	%
No written response	279	24.4	249	22.3	313	27.4	362	32.4
Written response	863	75.6	867	77.7	829	72.6	754	67.6

Independent sample t-tests indicate that there is no significant difference between the responses from primary girls and boys, but that there is a significant difference in the proportion of boys and girls responses at secondary school, boys making fewer written responses (see Appendix 6). The lack of difference at primary school suggests that the teacher may have encouraged everyone to write some comment and to give additional time if necessary. This suggestion is supported by primary teachers' feedback about the questionnaire when many positive comments were received about the usefulness of the questionnaire in preparing children for their SATs tests, and giving them opportunities to practise their writing skills. However, no such comments were received from secondary teachers, and the significant difference between boys and girls suggests that at secondary school those who did not make written responses may not have been able to write sufficiently quickly and/or fluently, or had little motivation to write; the research literature indicates that boys may find written work more difficult than do girls (Bleach, 1998; Clark, 1998; Murphy & Elwood, 1998).

In addition, children's feelings about science could have been a factor; children who disliked science might have felt inhibited about making written comments, which might be seen by their teacher and their peers. This possibility was investigated by comparing children's 'enjoyment of science' scores from the questionnaire with their written responses (Table 6-3).

Table 6-3: Qualitative & quantitative responses compared for children in years 6 & 7

	YEAR 6				YEAR 7			
	Makes no written response		Makes a written response		Makes no written response		Makes a written response	
Quantitative score indicates:	n	%	n	%	n	%	n	%
Does not enjoy	1	1.6	61	98.4	11	14.9	63	85.1
Not sure	19	7.1	248	92.9	34	10.7	284	89.3
Enjoys	99	7.9	1162	92.1	151	11.9	1114	88.1

Although there were slight differences in the proportions of children responding in each of these categories, independent t-tests tests indicate that these differences are not significant (see Appendix 6). So it seems unlikely that this was an important reason for non-response.

Secondly the amount and style of written response produced by different groups of pupils was investigated. It is possible that children who had difficulty with written work or who disliked writing would have been likely to write less in the free response section. Table 6-2 shows that at primary school the difference in the proportions of boys and girls making a written response is small, but at secondary school the difference is almost 5%, in favour of girls. Since, as indicated above, boys are generally less keen on producing written work than girls this may account for the gender difference observed in the secondary school responses. This possibility was investigated by comparing the number of text units used by boys and girls (a text unit is one line of written text rather than a number of individual words). This analysis is set out in Table 6-4, below.

Table 6-4: Average length of written response by gender

	Primary		Secondary	
	Girls	Boys	Girls	Boys
Number of written responses	863	867	829	754
Number of text units	1694	1493	3010	2369
Average number of text units	1.96	1.72	3.63	3.14

This table shows that the girls, on average, wrote more at both primary and secondary levels, and also that on average more was written at secondary school than at primary school. Thus it seems that boys, particularly secondary school boys, are likely to have written less or not made a written response. Reading the text through indicated another slight imbalance in terms of gender - boys were more likely to produce short sentences or simply a short list of words, whereas girls were more likely to write in sentences.

The procedure outlined above was also used to investigate differences in response based on social disadvantage, using the proportion of free school meals taken by schools; Table 6-5 summarises these analyses.

Table 6-5:Average length of written response by free school meals group

	Low FSM		Average FSM		High FSM	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Number of written responses	263	468	1000	436	465	667
Number of text units	1054	2248	1638	1595	537	1559
Average number of text units	4.01	4.80	1.64	3.66	1.15	2.34

Table 6-5 shows that children from disadvantaged areas are likely to have written less than children from more affluent areas. At both primary and secondary school, children from disadvantaged areas (high FSM) wrote less than children from more affluent areas (low FSM). Consequently it is suggested that social disadvantage has an effect on the amount and type of written comment produced. These differences in the amount and type of writing were addressed by a search for individual words rather than for sentences and phrases, as discussed above. Nevertheless, the difference in amount of writing will need to be taken into account when comparing the results of these analyses.

6.2 Main areas of comment by the children

Word searches were made of both the primary and secondary written responses for the 2258 children in the longitudinal sample. In the written responses of the primary school children were words describing what they anticipated at secondary school, and, once at secondary school, words described the actuality, as they perceived it. However, it must be borne in mind that, as Saatchi said 'satisfaction equals performance minus anticipation' (Thomson, 2001), and so children with very high expectations of secondary science are unlikely to be completely satisfied.

There were two reasons for obtaining and analysing these written comments: first to provide triangulation with the attitude questionnaire, and second to obtain further insights into children's feelings about science. The children made extensive comment about their feelings and these were generally linked with comments about particular aspects of school science. There were four major areas of comment:

- Facilities
- Teachers
- Learning/teaching approaches
- Curriculum/topics/subjects

Children's feelings will be described and discussed first, followed by the sections dealing with the linked comments about facilities, teachers, teaching and learning approaches and the curriculum.

6.2.1 FEELINGS/EMOTIONS

Word searches revealed that a variety of different words were used to describe positive feeling about science (see Table 6-6, below), and that some children used more than one word to write about their feelings. So, individual word counts are given as well as the overall count of individuals who made any positive response. As the table shows, there were many positive feelings expressed about secondary science, but the large range of positive words used by these children may represent different kinds of positive response.

Table 6-6: Positive words used about science by children in years 6 and 7

Positive views	**Primary**		**Secondary**	
	n=1730	%	n=1583	%
Good	30	1.73	34	2.15
Exciting	94	5.43	72	4.55
Interesting	92	5.32	141	8.91
Looking forward/prefer sec	16	0.92	30	1.90
Enjoy	51	2.95	106	6.70
Like	56	3.24	126	7.96
Fun	98	5.66	111	7.01
Brill/great/excellent/cool	3	0.17	7	0.44
Bad in primary, good in secondary (comparison)	3	0.17	91	5.75
Better	150	8.67	291	18.38
Positive responses per person (excluding 'better')	367	21.21	505	31.90

In particular, it seems possible that children who described science as better might not feel particularly positive about science, as the following comment illustrates:

> *1856 Science better here but I do not like it.* (Boy)

Furthermore, a comparison of the proportion of children in each category of 'enjoyment change' emerging from the questionnaire data using the word "better", shows that similar proportions of children in both the 'enjoy more' and the 'enjoy less' categories used the word "better" (Table 6-7).

Table 6-7: How the word better is related to changes in feelings about science

Pupils in each questionnaire category using the word 'better'					
Enjoy more N=296		**No change N=591**		**Enjoy less N=347**	
n	%	n	%	n	%
69	23.31	191	32.31	93	26.80

If all the positive comments are taken together, except for "better" [1], then almost a fifth of primary and a third of secondary children made positive comments about secondary science.

Table 6-6 shows an increase in the proportion of positive comment after transfer to secondary school; at primary school 21% expressed the view that secondary science *would be* a positive experience, once at secondary school this figure rose to 32% who were prepared to say that secondary science *was* a positive experience.

This increase of 11% can be compared with the attitude questionnaire scores, which indicate the number and proportion of the children who have become more positive about science lessons (Table 6-8).

Table 6-8:Changes in enjoyment of science from questionnaire responses

After transfer:	All questionnaire responses	
	n	%
Enjoys science less	196	12.9
No change	1181	77.8
Enjoys science more	368	9.3

The quantitative data indicating that 9.3% enjoy science more after transfer is quite close to the figure obtained from the qualitative data. However, when the proportion of negative comments (Table 6-9) is compared with the same quantitative figures (in Table 6-8) the same level of agreement is not found.

[1] Children often used more than one positive adjective, in particular, using 'better' and another positive adjective. So, although 'better' was sometimes used on its own, it seemed fairer to present it as a separate category.

Table 6-9: Negative words used about science by children in years 6 and 7

Negative views	Primary		Secondary	
	n=1730	%	n=1583	%
So-so	0	0.00	2	0.13
Don't like	1	0.06	21	1.33
Not fun	3	0.17	5	0.32
Not good	2	0.12	5	0.32
Bad in secondary school	15	0.87	40	2.53
Negative responses per person	20	1.16	38	2.40

The quantitative analysis suggests that 12.9% of children enjoy science less after transfer, but the written responses show an increase in negative comments of only 1%. This difference indicates that there were relatively few children who were prepared to write down openly negative remarks. Furthermore, the proportion of negative remarks about secondary science includes quite mild remarks such as,

> **128 It is a lot harder than primary school it is a bit better than primary school because they have more experiments and more things but it is still quite boring. (Girl)*

There were also a few explicitly negative remarks, such as,

> **540 It is still rubbish. I hate every lesson. (Boy)*

It is interesting to note that boys made more of the latter, negative comments, whereas girls made more of the former more moderate comments. (Attitude to science research in Australia (Rickards et al, 1997) has suggested that girls may be less willing than boys to make negative comments.)

It is possible that these children (both boys and girls) had tried to avoid making overtly negative remarks. This possibility was tested by comparing the positive and negative written responses, made by these children, with their enjoyment of science scores on the questionnaire (Table 6-10, below). When comparing these two different sections (Likert questionnaire and written response) percentages have been calculated against the total cohort (n=2258) rather than against the total number of responses made. This has been done because of the specific problem in these comparisons, of having two different 'total numbers of responses'; one from each section.

Table 6-10 shows that the larger proportion of positive response in writing coincide with scores on the questionnaire that indicate enjoyment of science. However, the same trend is not as obvious among the negative responses, although there are slightly more negative responses coinciding with negative scores on the questionnaire.

Table 6-10: A comparison of positive and negative responses: written and questionnaire

Total written comments in year 6 n=1730	Enjoyment of science from Year 6 questionnaire Total responses n=1883	
	Positive	Negative
Positive n	247	45
% (of n=2258)	10.94	1.99
Negative n	7	9
% (of n=2258)	0.31	0.40
Total written comments in year 7 n=1583	**Enjoyment of science from Year 7 questionnaire Total responses n=1815**	
	Positive	Negative
Positive n	387	44
% (of n=2258)	17.14	1.95
Negative n	5	33
% (of n=2258)	0.22	1.46

This evidence suggests that children may have deliberately avoided making negative written responses. To clarify this suggestion the apparently inconsistent responses (Table 6-10, in red) were examined in detail. This examination revealed that, at primary school, the 45 children who made positive comments, but scored negatively on the questionnaire were making positive references to secondary science, not to primary science, as this example shows,

> *229 *It sounds hard but good, it looks more interesting than our school, I think it will be good fun* (Girl)

This indicates that these children did not enjoy science at primary school but were looking forward to secondary science; Woodward and Woodward (1998) made a similar observation as a result of interviews with year 6 pupils.

Of the 9 negative responses from children at primary school with negative scores on the questionnaire, 8 made negative comments about secondary science; only one pupil was prepared to say that she disliked science, her comment is below.

**1509 We will use computers more, It will be a lot harder, you will have to do more of it on your own with out any help. People will know more about it than me because unlike the rest of my lessons I HATE SCIENCE! So I don't get very good marks. There will be new subjects. (Girl).*

In view of their remarks the following year, the others probably didn't like science at primary school either, but were more careful in their responses, as these two examples show:

**2114 <u>Primary school response</u>*

It will be harder. There will be more experiments, to do. There will be new things to learn. The invirement might be damaged more. It'll be borring (yawn!)!

**2114 <u>Secondary school response</u>*

It's still totally boring! (girl)

**907 <u>Primary school response</u>*

I think it will have us using computers more, difficult to understand, have new tecniqes of learning, have to do much much much more! Harder experiments, and also scienc may be a bit boring.

**907 <u>Secondary school response</u>*

At secondary school, it more interesting, and more fun. At Junior school it was confusing, harder and not very interesting because there wasn't any science equipment in [school] because lack of money in the school (girl).

So it would appear that, at primary school, some children were unwilling to make any directly negative remarks about primary school science.

At secondary level there were 5 negative responses by children who scored positively on the questionnaire. Of these only one pupil had nothing positive to say about science,

> *3267 *I dislike science. (Girl)*

The others included remarks suggesting that practical work made science more interesting, for example:

> *1280 *We actually do experiments and it is not as boring apart from that nothing has changed.* (Boy)

> ***1402** *Things that have changed; We use more interesting things like, microscopes, test tubes and bunsen burners. Also things have got complicated. Things that haven't changed; I do not really enjoy science that much (Girl)*

Perhaps the inclusion of practical work helped these children to feel less negative about science.

Within the group of 44 positive comments by children with negative scores on the questionnaire, thirty-one of these positive remarks were specifically about practical work or equipment, as these typical examples demonstrate,

> *1589 *Science at my secondary school is harder but more interesting. We do a lot more experiments than at [primary school], we have more science lessons at [secondary school].* (Girl)

> *269 *We used to just do easy and boring experiments, but now science is quite fun, most of the time.* (Boy)

The tone was quite cautious and phrases such as 'more interesting' and 'most of the time' were common. These children did not seem particularly positive about science lessons, only about practical work. In addition, the children's questionnaire responses (page193) showed that although, overall, attitudes to science declined after transfer, attitudes to practical work became more positive.

So, for both of the groups above, a dislike of science lessons may be moderated to some extent by enjoyment of practical work. On the other hand, perhaps these children did not want to make negative statements, and instead looked for something positive to say.

It is possible that the low number of negative comments at both primary and secondary school resulted from children choosing to make positive statements about practical work, rather than make a negative comment about science lessons. Nevertheless, these observations suggest that practical work has a positive influence on attitudes, and this interpretation is supported by the literature (for example, Woolnough, 1994b; Gott & Duggan,1995; Killerman, 1996; Speering and Rennie, 1996; Sutherland, 1996; Parkinson et al., 1998; Campbell, 1999).

6.2.2 THE EXPECTATIONS AND REALITY OF SECONDARY SCIENCE

The number of references to secondary school work being harder or easier than primary school work (Table 6-11, below) indicates clearly that the children in primary school expected secondary school work to be harder. However, the reduction in the number of such references once the children had moved on to secondary school, suggests that the work was less difficult than expected.

Table 6-11: Written responses about the expected and realised difficulty of science

	Primary		Secondary	
	n=1730	%	n=1583	%
Will be/is easier at secondary	1	0.06	18	1.14
Will be/is harder at secondary	758	43.82	253	15.98

There seemed to be an acceptance among the primary school children that the work would be harder at secondary school (only one reference could be found to work being easier); this seemed to be regarded as the natural course of events and for some, as a challenge to be relished, for example,

> *488 *I think the science will be harder. I also feel it will be fun as well.* (Girl)
>
> *506 *I think it will be harder but better and do more things* (Girl)
>
> *519 *Harder but more fun. More experiments* (Boy)
>
> *3295 *It will be quite hard but I will enjoy it I hope to learn new things and I can't wait.* (Boy)

References to the work being harder from children at secondary school did not appear to be particularly negative, and most children were generally accepting of the change, as is shown in these typical remarks,

> *2406 *The main difference is that we do more experiments than we did in Junior school. We also have to concentrate and work harder to understand things. We also have much more equipment than we did in Junior School. The things that stay the same are - we are taught science, instead of the seperate sciences, we do a fair amount of writing in our books and we still have the occasional test. I probably enjoy science better at secondary school than I did at Junior School.* (Boy)
>
> *3361 *Science in secondary school is a lot harder Science in Secondary school is more interesting. I prefer science in secondary school than when I was in primary school. It was a lot easier in primary school. We didn't do much science in primary school.* (Girl)

Whereas, learning new things seemed to be viewed positively:

> *2132 *In primary school experiments are less interesting. We didn't learn as many things as we do now.* (Girl)

Earlier qualitative research offers contradictory evidence on this issue: Hawkey and Clay (1998) and Sutherland (1996) found that children thought science was harder at secondary school, whereas Campbell (1999) said that all except one of the children questioned felt that science was easier at secondary school. These findings could simply reflect differences between schools; both Hawkey and Clay, and Campbell conducted their studies in a single school. However, Sutherland's work involved 12 secondary schools, but in each school only a small group of pupils were interviewed, and so the different findings may reflect differences in sample sizes. Furthermore, Sutherland noted that these children did not regard increased difficulty as the cause of difficulty, and that has also been found in the present study.

The relative proportions of comments about science being 'hard' or 'easy' may offer a clue as to why some children dislike science at secondary school. Only 18 references to science being easy (1% of the children) were made at secondary school, but 240 references to science being 'hard' (16% of the children). Certainly there is a greater emphasis on difficulty than on facility. However, the comments about the difficulty of science fell into two categories, those who found the increased difficulty a source of stimulation and those who found it a source of concern. The following comments illustrate these two categories of response:

> **790 Well, the science in my secondary school is much, much harder but I love it* (Girl)
>
> **1510 It is harder but more fun because we do more experiments (Boy)*
>
> **2096 Science at Secondary School is harder, more boring, more competat [complicated] and rubbish (Boy)*
>
> **3260 Science is more harder at secondary school, but it's more boring than primary school! (Girl)*

A small number of children expressed anxieties and fears about science at secondary school: 29 at primary school and 10 at secondary school. Perhaps children with worries chose not to write about them, but the decline in such comments after transfer suggests that most children had adjusted quite well to secondary science.

6.2.3 THE CHANGE IN ATTITUDE ON TRANSFER

An unexpected type of comment appeared in the secondary school writings denying having done science at primary school (Table 6-12).

Table 6-12: Written responses about primary science & qualified science teachers

	Primary		Secondary	
	n=1730	%	n=1583	%
Deny doing science at primary school			213	13.46
Deny doing experiments at primary school			142	8.97
Negative comments about primary science			110	6.95
Qualified science teacher at secondary school	33	1.91	35	2.21
Proper/real science at secondary school	25	1.45	38	2.40
Total negative references to primary science	58	3.35	538	33.99
Positive comments about primary science			19	1.20

More than 20% of these children said that they had never or hardly ever done science at primary school. Two examples of such comments are given below.

> *2138 *Science is better here than at primary school because we get to do experyments and we do this in more detail and at primary school we didn't do any thing on science we just talked about it we NEVER done any thing on the subject. (Girl)*

> *1427 *I think science is really good here as we never did any thing in junior school, this is interesting and resonably entertaing (Boy)*

In total, these children made 538 negative references to primary science in their first year at secondary school (i.e. 34% of the total number of secondary responses), compared to only 19 positive references (i.e. 1% of the total responses). These comments referred to having done no science/hardly any science/no experimental work at primary school, to teachers who knew little about science, and to primary science as uninteresting or 'not real' science. Typical of such comments are the following:

> *2574 *It is more interesting than last year we do a lot more experiments. The experiments we did last year were rubbish but now I'm enjoying experiments because we have better equipment. (Boy)*

*2941 *We learn things in more detail. Computers are an important part of our learning It is much more exciting + enjoyable. You get to use proper equipment and are trusted to use it properly. We have more resposibilites in the classroom. Its fun. We learn more. Things are made clear and you cant do anything without understanding properly. Primary School Science is BORING AND STUPID COMPARED To SECONDARY SCHOOL SCIENCE. (Girl)*

*1875 *We did not do much science in [primary] because the teachers are no good at it. (Boy)*

*1918 *I think science this year is better because we have more equipment to use and the teacher is normally only a science teacher so he/she knows more than a junior school teacher. (Girl)*

When comments denying and disparaging science are taken together, it seems possible that a major change has taken place in the perceptions of these children on transfer, and that a large proportion of these children (over 30%) now feel that primary science was:

- Not interesting
- Not enjoyable
- Not science

More than one interpretation of these comments is possible; perhaps science was *not* taught at primary school, but if not then various questions arise.

For example:

- Why was the school doing no science?
- Why did the children write about science when they were in year 6 as if they were already doing some?
- Why did children from such a wide variety of primary schools make similar comments?

It was thought possible that the references to not having done any science might relate to the way science teaching had been organised at primary school. As suggested in Chapter 4 (page 227), perhaps children who had been taught using the topic-based approach might not have understood what was meant by 'science lessons' during the first survey. In order to check this, data were inspected to establish which schools the children making these denials were from. However, it emerged that some children from *every* primary school had made such comments, and 44% of all denials came from children who had *not been taught* using a topic-based science at primary school. So these data tend to refute the idea that the children denying doing science at primary school had not known when they had been doing science at primary school, since for many of these children science had been a timetabled subject.

An alternative interpretation is that secondary school science is so different from primary school science that these children now look back on their primary years and wonder what it was that they had been doing. This idea is supported by comments such as the following:

> **3054 Science is harder and more challenging now, we have more equipment so science is fun now. It used to be quite boring thinking back on my primary years. Our new teacher is fun and won't boss you around a lot. (Boy)*

> **224 Science at secondary school is fun, you don't write page after page, and you get to try new things. I don't think we ever done sience last year any way, if we did it was dreadful! (Girl)*

Furthermore, comparing primary school questionnaire scores with those primary and secondary written responses, indicating that primary science had not been enjoyable, suggests that an important change of attitude may have taken place for most of those children, (Table 6-13). At primary school only one pupil made a negative response about primary science. However, at secondary school, 110 children (i.e. 5% of the cohort) were negative about primary science; the majority of them having responded positively to the year 6 questionnaires, this finding is supported by that of Campbell (1999).

Table 6-13: A comparison of written & questionnaire responses about primary science

	Enjoyment of science from Year 6 questionnaire Total responses n=1883			
Written responses	Positive	Not sure	Negative	No response
Negative about primary science in year 6 n	0	0	1	0
% (of 2258)	0	0	0.04	0
Negative about primary science in year 7 n	68	9	16	17
% (of 2258)	3.01	0.40	0.71	0.75

There seem to be two possible interpretations of this finding: first, that these children were not truthful in their questionnaire answers in primary school, or in their written responses in secondary school; or second, that their attitudes to school science have changed completely.

The first possibility, that these children were not truthful in their responses, seems unlikely. The evidence above has suggested that although in written responses children were probably very cautious about their *current* school there is no evidence to suggest that in retrospective writings children were as careful. Comparisons on questionnaire scores against written responses indicate a good match for positive responses, and for negative questionnaire responses the written responses are careful, or very slightly negative, but not positive. Thus, the evidence suggests that these children were unlikely to lie in either written responses or questionnaire responses.

The second possibility, that attitudes may have changed radically, appears more likely, particularly when the recent attitude change theories of Fazio (1990) and Petty (1995) are considered (See Chapter 1, page 55). Attitudes are likely to remain stable when the attitude is formed after experience with the attitude object, but are likely to be changed easily when the attitude object has not been experienced.

So what makes the experience of secondary school science so different from primary school science that for some children attitudes undergo such a radical reappraisal?

The improved facilities, which allow more experimental work, are a major source of comment; many children feel that more and better experiments take place at secondary school. Over 58% of children talked about practical work and over 13% made a direct comparison between practical work at primary and at secondary school. For example:

> *2796 *At my old school we did'nt do expiements, with bunsen burners and other ekqiment in secondary school. We used texed books sometimes but not always we did'nt write up expirments we did'nt have benches or stool's. I think I like doing science at this school best at my other school it was a bit boring but I like it here becuse we do lot's of expiment's. (Girl)*

> *2574 *It is more interesting than last year we do a lot more experiments. The experiments we did last year were rubbish but now I'm enjoying experiments because we have better equipment. I also like working in small groups in our old school we did the whole experiment as one big class group (Boy)*

The overwhelming numbers choosing to talk about practical work and equipment suggest that, at this stage, children may still be enthralled with the newness of laboratories and the accompanying apparatus. The survey was not made until halfway through Year seven specifically to avoid the first enchantment of such things. However, it seems possible that this fascination continues for longer than was supposed. This may explain the pupils' apparent belief that they had not done science; the apparatus and laboratories are very different from what they used in primary school. These results are similar to those of Jarman (1993).

However, the small group of 19 children who, at secondary school, said that they had preferred primary science made some very particular points about the way they were being taught at secondary school. They spoke for example, of lack of clarity in explanations:

> *2108 *Secondary school has a lot more equitment and the science we learn is different from our last school. We have to use the scientific words for chemicals and in primary school we didn't. In Secondary School it's much harder to understand what the teacher's telling us. In both school we did experiments but we don't do as many as we used to. (Girl)*

They also spoke of their role in science lessons as being too passive,

> **1186 I liked it better last year because science in this school is boring becuase we do to much listening and writing to be able to learn anything. And our teacher last year explained it a lot more clearly. (Girl)*

And of science being harder than at primary school:

> **447 The science we do in this school is a lot harder and we don't always do as much as we did in our primary schools. The teachers don't always explain it as much as they did in primary school. (Boy)*

These comments indicate that the quality of teaching is likely to be very important for these children. An examination of the negative comments about primary science teaching indicate that many children appeared to feel that the teaching had changed for the better as well as the facilities, as is demonstrated by the following typical comments:

> **1286 The difference is what we did in our junior school is that we do many experiments and learn lots of new things. We have more science lessons at [secondary school] then we did at [primary school]. We learn different kinds of words and what each piece of equipment. Where in our junior school we just used the equipment without knowing what it is. My teacher Mrs [B] does explain many things or should I say every clearly so I understand it and work safely. (Girl)*

A number of children gave specific reasons for their views that secondary science was better than primary science. Although derived from only a subset of the data (454 children), these reasons offer valuable insights into the factors responsible for attitude changes. The comments were analysed and the results are presented in Table 6-14 below.

Table 6-14: Written responses giving reasons for preferring secondary science

	Primary		Secondary	
Reason	N=1730	%	N=1583	%
Experiments	20	1.16	116	7.33
Equipment	43	2.49	93	5.87
Haven't done science before	3	0.17	58	3.66
More interesting	0	0.00	31	1.96
Learning is improved	0	0.00	27	1.71
More activity	0	0.00	27	1.71
Teachers and teaching	13	0.75	21	1.33
Easier writing	0	0.00	10	0.63
Harder	13	0.75	8	0.51
Danger	8	0.46	8	0.51
Being older	15	0.87	5	0.32
Understanding is improved	0	0.00	4	0.25
Group work	5	0.29	3	0.19
Easier	0	0.00	3	0.19

The most frequently mentioned reasons for enjoyment were the better facilities and the increased opportunity for experimental work. These were also the most often mentioned expectations at primary school, and, as can be seen from Table 6-14, the number of these references increased appreciably at secondary school. Two typical examples follow.

**802 Primary school response*

Chemicals, more equipment, it will be more interesting, more exciting experiments.

**802 Secondary school response*

Secondary school is better because we use different equipment, the experiments are better, and we use more stuff to do them - it is more exciting. We use computers, sometime the experiments are varied and we use chemicals which make it exciting. (Boy)

**2138 Primary school response*

We will prodly do experments when we are older. more equipment to use and more experiants teatcers for diffrant lessons.

**2138 Secondary school response*

Science is better here than at primary school because we get to do experyments and we do this in more detail and at primary school we didn't do any thing on science we just talked about it we NEVER done any thing on the subject. (Girl)

The next most common reason these children gave was that they had never done science before; this has already been discussed, but it is interesting to note that only 3 primary school children gave this as a reason for expecting to enjoy secondary science. This evidence certainly suggests that, when at primary school, children were likely to think that they *were* doing science, and only after transfer did this view change.

Of the numerous other reasons given, the largest number referred to teachers, teaching methods and understanding. (Table 6-15 is an edited version of Table 6-14 to show the effect of combining similar ideas).

Table 6-15: Reasons for preferring secondary science (combined categories)

	Primary		Secondary	
Reason for preferring secondary science	N=1730	%	N=1583	%
Teachers and teaching	13	0.75	21	1.33
Learning is improved	0	0.00	27	1.71
Understanding is improved	0	0.00	4	0.25
Easier	0	0.00	3	0.19
Easier writing	0	0.00	10	0.63
Harder	13	0.75	8	0.51
All learning and teaching references	26	1.50	73	4.61
More activity	0	0.00	27	1.71
More interesting	0	0.00	31	1.96
All motivating references	0	0.00	58	3.66
Being older	15	0.87	5	0.32
Danger	8	0.46	8	0.51
Group work	5	0.29	3	0.19
All miscellaneous references	28	1.62	16	1.01

Two typical examples are given below.

> *3253 *I think science lessons are much better at secondary school than junior school, because the teachers know more about the subject and have more facilities (Boy).*

> *705 *In secondary school we have a lot more equipment than I did before and because we have teacher that has learnt all about science and not other subjects as well. So Mr [B] knows more about science than Mrs [A]. (Girl)*

The 'motivating' references (more interesting and more activity) were not mentioned by children at primary school and may subsequently have been a revelation to these children.

Typical examples of such responses are:

> *2144 *I did very little science at my old school. At my old school we hardly ever did any experiments, and so I found it rather boring as I like finding out things my self and actually seeing what happens. I enjoy science at secondary school as we do lots of different experiments, as well as doing written work. (Girl)*

> *802 *Secondary school is better because we use different equipment, the experiments are better, and we use more stuff to do them - it is more exciting. We use computers, sometime the experiments are varied and we use chemicals which make it exciting. (Boy)*

The pattern which emerges from the analysis of this sub-set is similar to that obtained from an analysis of all the free response data (Appendix 6), where the major areas of comment found linked with children's feelings were facilities, teachers, teaching approaches, and the curriculum.

6.2.4 Facilities

Table 6-16 shows the proportion of references by children in primary and secondary school to the facilities expected and found at secondary school. The number of references to experimental work and equipment highlights their importance.

Table 6-16: Words/comments about facilities from children in years 6 and 7

Primary school N=1730	**n**	**%**	**Rank**	**Secondary school N=1583**	**n**	**%**	**Rank**
Equipment (general)	523	30.23	1	Equipment (general)	599	37.84	2
Experiments	467	26.99	2	Experiments	814	51.42	1
Computers	334	19.31	3	Computers	70	4.42	4
Laboratories	148	8.55	4	Laboratories	60	3.79	5
Books	124	7.17	5	Books	82	5.18	3

The similarity in ranking and number of comments at primary and secondary school indicates that, in most cases, children's expectations when at primary school about the facilities at secondary school were probably quite realistic. Induction procedures and open days may account for this convergence, suggesting that the schools attended by these children were successful in preparing them for the changes in the physical environment.

The primary school children in this sample were aware of the wide range of equipment which they expected to use at secondary school. For example:

> *591 *Bigger rooms, better equipment, a wider selection of chemicals and experiments, more computers to work with, better teacher to for science. (Boy)*

> *676 *1. We will have more equipment. 2. We will do more things with computers. 3. We might have to go to a special place. 4. We might use chemicals to do experiments. 5. We may have to wear aprons because of the chemicals. 6. We might have to sit on stools because the benches are every high. (Girl)*

There was also a clear expectation that a considerable amount of practical work would be involved, much more than occurred at the primary school. For example:

> *683 *We will be able to use more equipment 2. We will be able to use more chemicles. 3. we will have a bigger area to work in. 4. We will have more equipment. 5. We will have glass chemicles holders. 6 There will be people who will help us to put out equipment. (Boy)*

> *3219 *We will use lots of different equipment. We will do some exciting things probably more exciting than what we do here. We will do lots of experiments and investigations. I think it will be very different. (Girl)*

At secondary school experimental work and the use of specialist equipment were areas for particular comment; over 50% of the children commented on experimental work, and over 40% of children made comments about equipment, when laboratories are included. Often a positive linking adjective or explanation accompanied these words. For example, words such as proper, real, better, specialist, and special were frequently used.

> *192 *we do better experiments at this school (Girl)*

> *1069 *Science is much better here because we do proper experiments. (Boy)*

The tone and number of the comments made suggests that the majority of these children regard secondary science as better than primary science because of the experimental work, the specialist equipment and the specialist teaching.

> *3039 *Work on materials is nearly the same, but science is better at secondary school because we do better experiments. The teaching method is different, but for the better. (Boy)*

> *2472 *I think science is a lot better here because I have certain qualified teacher to teach me. And I also like this type of science more because get to use proper and better equipment and it is more fun. (Girl).*

The figures in Table 6-16 above show that the number of references to computers declined dramatically. At primary school 20% of children mentioned computers, but only 5% referred to computers at secondary school. This difference may reflect the reported difference in the frequency of use of computers discussed earlier (page 211); these children observed a dramatic decrease in their use of computers in science once at secondary school. Therefore, the large number of references to the expected use of computers probably reflects their current usage of computers, and the fall in the number of references reflects the reduction in their use.

The secondary school references were often somewhat sad reflections on the lack of computer use; the example below is typical of 15 such comments.

> *2026 *The science in this school is harder, more interesting, more equiptment used, more lessons of it. In the junior school we used computers but unfortuanatly we dont here. (Girl)*

**1728 There is much more practical equipment in secondary school. No computers are used, I haven't used one in science yet. Science over all is very interesting and exciting. (Boy)*

There were only four positive statements, and these were all from children in the same school, suggesting that the school might be unusual in its high use of computers in science. Here is one example,

**2941 Computers are an important part of our learning. It is much more exciting + enjoyable. (Girl)*

6.2.5 THE TEACHERS

Although specific references to teachers were less common than those to practical work and equipment, they were mentioned by a considerable number of children at both primary and secondary school (Table 6-17, below). When these responses were classified and calculated as percentages of the total number of teacher references, the anxieties preceding transfer and their subsequent resolution became apparent.

Table 6-17: Written references to teachers in years 6 and 7

Primary school N=1641	n	% (of 1730)	Secondary school N=1557	n	% (of 1583)
All references to teachers	184	10.64	All references to teachers	234	14.78
	n	% (of 184)		n	% (of 234)
Specialist science teacher	52	28.26	Specialist science teacher	41	17.52
Different teacher	50	27.17	Different teacher	9	3.85
Stricter teacher	40	21.74	Stricter teacher	8	3.42
Teachers won't help you	14	7.61	Teachers don't help you	8	3.42
Teachers will help you	10	5.43	Teachers help you	14	5.98
Feelings	7	3.80	Feelings	27	11.54
Teacher will do the experiments	5	2.72	Teacher does experiment	9	3.85
Explaining/understanding	5	2.72	Explaining/understanding	61	26.07
Miscellaneous	1	0.54	Miscellaneous	5	2.14
Pupil will do the experiments	0	0.00	Pupil does experiment	52	22.22

At primary school, the main preoccupation was with having a different teacher who would be qualified to teach science (55% of pupils mentioning teachers). These new teachers were expected to be stricter and less helpful than those at primary school. These are typical examples,

> *826 *We will use more Scientific instruments and will have a different teacher who noes only about science. (Girl)*

> *2768 *You go in a lab, it's harder, there are more classes, you get specialists and better teachers. (Boy)*

> *52 *I think it will be more complicated and strict. I think the experiments will be bigger and harder. I think that the teachers will not help as much as they do in junior school. I think that we will have to study harder to get good marks on our exams and I think we will get a lot of homework (Girl)*

However, once at secondary school there were few references to strict teachers or lack of help, and although there were still a fair proportion of references to qualified science teachers, more of the comments focused more on the specialist nature of these teachers. The other obvious change was the increase in the number of responses referring to clearer explanations by teachers (mainly by girls). The following responses illustrate these changes.

> *3253 *I think science lessons are much better at secondary school than junior school, because the teachers know more about the subject and have more facilities. (Boy)*

> *2472 *I think science is a lot better here because I have certain qualified teacher to teach me. And I also like this type of science more because get to use proper and better equipment and it is more fun. (Girl)*

> *2115 *I think that science at secondary school is better because its more interesting and you get to use better equipment. Also I think its explained better (Girl)*

The comments suggest that these children felt that having a specialist teacher in science was a positive advantage, and also that they saw it as a difference from primary science.

The other major change within these responses was in the number of references to doing experiments rather than to watching the teacher and writing.

As Table 6-17, above shows no pupil talked about doing experiments at primary school, but at secondary school 22% of pupils, referring to teachers, mentioned this.

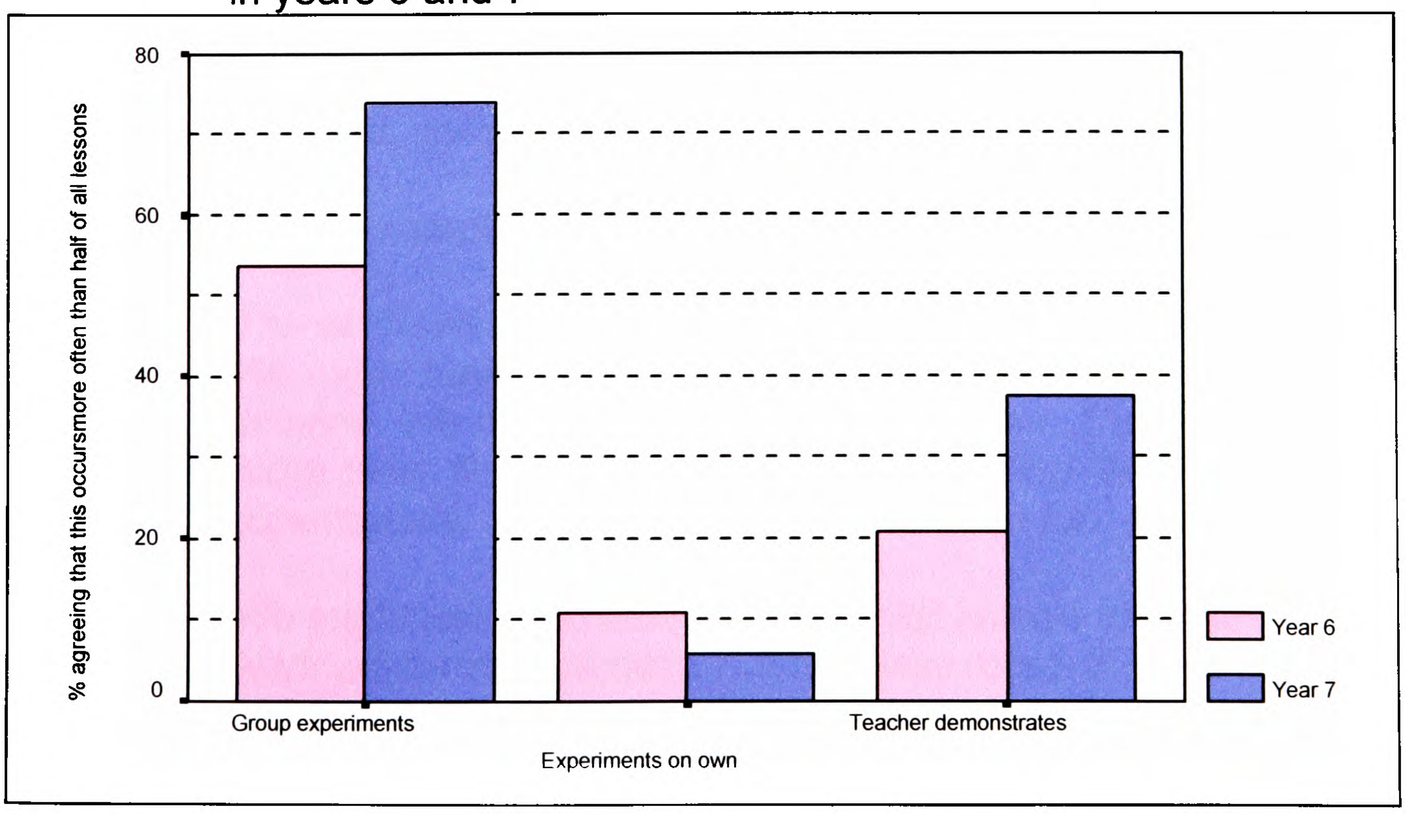
The following examples are typical of the comments made,

> *1939 *In my last school we did not do many experiments. Not like now, we do them every lesson and we did not do them, the teacher did but now we do them in groups. (Girl)*

> *90 *We get to do more things at secondary school, at primary school we had to sit around and watch the teacher do all the things. (Boy)*

These comments illustrate two possible reasons why these children enjoy experimental work: it allows them to move about instead of having to 'sit around and watch', and it also gives feelings of greater autonomy. Both of these points will be returned to in the next section on 'ways of working'. These responses suggest that the teachers at primary school did not allow the children much opportunity to do practical work, and that science consisted mainly of teacher demonstrations. However, this seems to be at odds with the pattern found in the questionnaire responses (Figure 6-1).

Figure 6-1: Frequency of use of different approaches to experimental work, in years 6 and 7



Although these children have more opportunities to do practical work in groups at secondary school, there is also an increase in the frequency of teacher demonstrations, and a reduction in opportunities for individual practical work. However, at secondary school demonstrations may be used as an introduction to practical work in groups, as some of the children point out,

> *46 *We watch the teacher have a bash first. (Girl)*

But at primary school teachers may use demonstrations as an alternative to practical work by the children, as suggested by this response.

> *2971 *Well in Science last year we did watching experiments and this year we do practicals ourselves. (Boy)*

Perhaps some primary teachers used demonstrations because they lacked confidence in their own ability in science; alternatively it could be the result of insufficient equipment and time. Such responses might explain why secondary school children were negative about primary school science (page 357).

Among the primary school children there was an acknowledgement that they would meet a variety of different teachers each day. For the most part these comments did not seem to have any particular feelings attached to them; it did not seem to be a cause for worry nor yet for celebration, it was simply a fact. However, as mentioned earlier, some children expected to have stricter (22%), less helpful (8%) teachers, for example,

> *35 *The work will be harder. We might have to write things down more. We might have to use computers more. We could have more tests on science. We might have science more often. The teacher might be more strict. Science might be very interesting. We might do more experiments. Science could be much more fun. (Boy)*

> *3337 *We might use chemicals, the work will involve lots more writing, the work will be in a lab not a normal class room, the teachers might be stricter, we might have to think a lot instead of listening. (Girl)*

**2474 Computers, Not that much help, harder things, more things to do (Boy)*

**2719 I think that the science will be harder, I think that the teacher will not help us so much, I think that the science will be totaly different (Girl)*

These comments reflect an element of concern, perhaps about the loss of a familiar primary teacher or about a new regime where more formal behaviour would be required, or where a particular teaching style might be more prevalent. However, once at secondary school there were few comments about stricter (3%) and less helpful (3%) teachers, indicating that this concern was generally unfounded. In fact, help from teachers was more often mentioned at secondary school (but only by girls). Here is one example,

**3191 We learn a lot more and if you dont understand they will help you as much as they can. So I like it beter at this school. (Girl)*

Such a balance of comments suggests adjustment rather than concern.

The increased incidence of comment about teachers after transfer may be of note; after all children generally become close to their primary teacher, who they are with for most of the school day, and yet most of the children refer to their secondary science teachers rather than to their primary teacher. So it seems possible that these pupils regard their secondary teacher as more important than their primary teacher in the context of school science. In addition, many of these children said that primary science was not interesting and not science (see page 355), and these two issues might indicate pupils' preference for specialist science teaching. But this remains a tentative suggestion, since only a small percentage of the children responded in this way, and there were some who felt that their primary teachers were better able to teach them science.

6.2.6 LEARNING AND TEACHING STYLES

As well as referring specifically to teachers, many children commented on aspects of secondary science teaching, without using the words teacher or teaching, these comments are categorised in Table 6-18. Although these children seemed to be quite well prepared for the changes in their physical environment they appear to have had a much less clear view about what learning and teaching activities might be expected at secondary school.

Table 6-18: Written references to ways of working at primary & secondary school

	Primary school N=1730			Secondary school N=1583		
Ways of working expected	**n**	**%**	**Rank**	**n**	**%**	**Rank**
Independence/responsibility	145	8.38	1	117	7.39	3
Do more work/ work harder	109	6.30	2	52	3.28	6
Writing	89	5.14	3	244	15.41	1
Homework	76	4.39	4	26	1.64	10
Tests	75	4.34	5	32	2.02	8
Learn more/learn new things	57	3.29	6	96	6.06	4
Group work/discussion	50	2.89	7	91	5.75	5
Knowledge/facts	30	1.73	8	14	0.88	12
Vocabulary	26	1.50	9	23	1.45	11
Work faster/ less time	21	1.21	10	7	0.44	13
Understanding	14	0.81	11	39	2.46	7
Complexity	4	0.23	12	30	1.90	9
Repeated work or concepts	4	0.23	13	135	8.53	2

If Table 6-18 is compared with Table 6-16, it can be seen that at primary school, children made far more comments about facilities than about ways of learning, suggesting that this was not something that they had thought much about. However, after transfer there were considerably more comments about the way learning was experienced, and the changes in both number and ranking of these responses suggests that some of these ways of learning might have been unexpected.

Independence and writing were clearly important to children at both primary and secondary school, since their ranking was in the top three in both cases. However, other topics changed rank quite considerably; in particular more work/working harder, homework and tests became less important, but repeated work became more important.

The responses categorised as independence/responsibility are concerned with autonomy, as are some of the other categories: group work, discussion and pupil involvement in practical work allow some freedom, but teacher demonstrations are controlled. The responses concerning independence/responsibility, group work/ discussion and demonstrations are combined in Table 6-19. In this new table responses concerning freedom and control increase to 12% in primary school and to 16% at secondary school, which makes this an important group of comments dealing with the context of science lessons.

Table 6-19: Written responses about autonomy in years 6 and 7

	Primary school N=1730		**Secondary school N=1583**	
	n	**%**	**n**	**%**
Independence/responsibility	145	8.38	117	7.39
Group work/discussion	50	2.89	91	5.75
Teacher does experiment	6	0.35	3	0.19
Pupil does experiment	4	0.23	39	2.46
Autonomy –total comments	205	11.85	250	15.79

At primary school many children talked in non-specific terms which suggested an expectation of independent work, as the following examples show,

**3308 I think it will be harder but better because we get to work on our own. (Girl)*

**414 Work on your own to do science and experiments. Use computers. (Boy)*

However, once at secondary school many children seemed to feel that they had more autonomy, for example:

**262 Now that we are in secondary school we do a lot more science than before, we also have a different teacher who is specialised in science, we are allowed to use a bunsen burner. We also didn't do very much our selfs, the teacher did most of what we did, all we did was write up the experiment. (Boy)*

*1073 *Science is different because we use bunsen burners, tripods, gas, glass, flammable liquids, dangerous substances. At junior school the teacher woud have to heat the liquids and do nearly every thing for us, at secondary school in science the teacher seems to trust us more and give us independance. At secondary the teacher lets us find out things for our selfs, plan the investigation. At junior school the teacher would sometimes give us a worksheet with the information on so we didn't have to do the experiment. I think we should do more science at junior school so we under stand a bit more at secondary school. Teachers in primary school treat school us like infants when it comes to science. (Girl)*

But for other children there seemed to be little change:

*410 *Same things = teacher does the big experiments. Teacher does the powerful one for the tests. (Boy)*

*2174 *We still do experiments in groups and some times copy charts or writing from the board, and the teacher some times shows us what to do as well (Girl)*

However, responses like these were few in number and the majority referred to greater autonomy. Sutherland (1996) reported similar findings. The children in this sample appear to view secondary science as consisting essentially of student directed practical work with specialist science teachers in custom-built laboratories. By implication, there seems to be a strong sense that very little 'real' experimental work is done in primary school, and that primary teachers do not have science training or do not have an understanding of science.

Writing was mentioned by only 89 children in primary school but by 244 at secondary school. At primary school children expected that there would be more writing after transfer, for example,

*3205 *I think next year that science will be very fun apart that I think there will be a lot of writing involved. (Boy)*

*359 *We will use books, choose our own experiments to do, talk about it more, be in groups, harder experiments, more writting. (Girl)*

However, once at secondary school perceptions of the amount of written work varied considerably (Appendix 6). Many children mentioned writing, some thought it was easier or there was less to do (3%), others found it harder, or said there was more to do (3%), while a larger group said writing was the same as at primary school (5%).

One typical example from each of these groups follows[1].

> *253 *We use a lot more equipment now, like bunsen burners. We use computers for some times but we didn't used to, we have to write up experiemnts fully and it is harder to write them up. We learn more scienctific words, we didn't have to do science three times a week at our old school. Some times science lessons are boring but sometimes they are fun. (Girl)*

> *1287 *I like science a lot more now I am at secondary school because at junior school it was a lot more just writing what was on the board. Here we do a lot more experiments and working out for ourselves. The thing that is the same is you have to write up your experiments but I like doing that because I like English. (Girl)*

> *3233 *At [primary school] we didn't do a lot except write. We never did any experiments. At [secondary school] though we get to do lots of experiments. And we don't have to do loads of writing. We also get to do really exciting things (at [secondary school]) including making Rockets and setting them off. (Girl)*

These responses support the questionnaire data where it was found that, on average, children's views about written work in science did not change significantly on transfer, and that opinions were divided: 38% agreeing that writing was more difficult and another 42% disagreeing, the remaining 20% finding no particular change. Sutherland also found mixed views about writing in science, supporting the present findings. The changes in the amount and difficulty of written work may reflect the teaching style of a particular teacher.

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[1] Since there is believed to be a difference in attitudes to writing for boys and girls, the comparisons between these groups use responses from girls in each case.

Repeating earlier work may have been a surprising change for some of these children; at primary school only four pupils thought that work might be repeated next year (Table 6-18, p.376). The example below illustrates this latter point of view.

> *737 *I do not think science will be different because we probably done them in the juniors. (Girl)*

However, at secondary school 135 children referred to repeated work (9%). Occasionally this was referred to in a disparaging way, as in this example,

> *692 *We hardly did science at school last year, we only did about lighting light bulbs. Some of the science I do is fun and some is boring, and stuff about what I know. (Boy)*

But more often children seemed quite pleased that they knew something about the topic under discussion:

> *2726 *Some of the things we do I already know from last year, but some of the things I don't know, but it is good to learn the things again. (Girl)*

So, although children might not have expected to repeat earlier work, it does not seem to have posed a particular problem for most of them. These responses illuminate the questionnaire responses to the 'perceptions of continuity and progression' items (Table 4-2, page 193), which indicated that, on average, there was little change in opinion about these issues on transfer. The slight increase in the percentage of children who thought that they already knew most of the science done after transfer (4%), was counter-balanced by the percentage of children who thought that the ideas were harder (3%). On the whole these responses suggest that although some of the topics might be familiar the approach may have been less so. At primary school 4% of children said that they expected that there would be lots of tests in secondary science (Table 6-18, p.376), but after transfer the proportion mentioning tests fell to only 2%.

Typically, at primary school, the references to tests would be like this one,

> *1664 *I think the science next year will be harder, I think we will have more tests on science next year.*

The secondary school comments about tests were more varied, and were found for single individuals, randomly spread across different schools. These individuals talked about tests as being: the same as last year, less frequent than last year, more often, or useful, as the following examples show.

> *2406 *The things that stay the same are - we are taught science, instead of the seperate sciences, we do a fair amount of writing in our books and we still have the occasional test. I probably enjoy science better at secondary school than I did at Junior School. (Boy)*

> *1750 *We do a lot more experiments than we did in the junior school. We also do a lot more tests on what the topic is. It is quite a lot harder as well. (Girl)*

> *35 *We do a lot more experiments than last year. We still copy work from the board. We do not have as many tests as we used to. It is more fun doing science in secondary school. (Boy)*

> *1297 *Science now is more interesting and we use more and better equipment to see the different conclusions. [secondary] school science teachers explain the experiments more than the primary school teachers. We also do better tests and they help explain the work we are doing. (Girl)*

There were six comments from a single school about having more tests, suggesting that this school might have placed a greater emphasis on testing. However, even these comments were not particularly negative as the following example shows,

> *2151 *The things that are the same is you write down things in your book. The things that are different is you get do much more tests and quite a few experiments. I prefer Science at secondary school than at primary. (Girl)*

Such written comments suggest that these children do not regard testing in science as problematic after transfer. Although they expected more testing, in reality it appears to be very much the same as it was at primary school. This finding supports the evidence from the children in Section 3 of the questionnaire (see pp.212-213).

6.2.7 CURRICULUM/TOPICS/SUBJECTS

Responses concerning the curriculum were generally comparative, and dealt with similarities and differences between primary and secondary science topics (Table 6-20). Overall there were more references to similarities than to differences suggesting that many of the topics in secondary science may have been familiar to many of these children. It is possible that the introduction of the National Curriculum may be responsible for this familiarity.

Table 6-20: Comparisons of curriculum areas made at secondary school.

	Similarities		Differences	
Secondary school responses N=1583	n	%	n	%
General references to curriculum/subjects/topics.	174	10.99	52	3.28
Chemistry	15	0.95	74	4.67
Biology	19	1.20	3	0.19
Physics	63	3.98	0	0.00
Total curriculum comparisons	271	17.12	129	8.15

The relatively large number of references to similarities in physics, and the lack of *any* references to differences suggest that this is an area that has been extensively covered at primary school. Likewise, many biology topics may also have been met in primary school. In contrast, chemistry is a subject that seems to have received relatively little attention in primary school since very few children mentioned similarities (1%), whereas differences were mentioned by almost five times this number (5%).

When *all* curriculum references are counted, rather than just those involving comparisons (Table 6-21), chemistry receives by far the most. However, many of the chemistry comments referred to 'chemicals' rather than to 'chemistry', particularly at primary school (82%)[1].

Table 6-21: Subject references in years 6 and 7

Subject references	Primary school N=1730		Secondary school N=1583	
	n	%	n	%
Chemistry	313	18.09	357	22.55
Physics	70	4.05	122	7.71
Biology	67	3.87	91	5.75
All subject references	450	26.01	570	36.01

The majority of these subject references were purely descriptive, with very few judgemental comments; this is a typical example,

> *3034 *At my old school we did lots of science, but we did not use chemicals. We did about plants and animals, "living things", we did biology, a topic on growing and changing, and we looked after fish and gerbils. We also did lots of work on things such as light, energy and electricity. We did not do experiments like we do now, with bunsens and goggle and things. But we did experiments and write-ups about them. (Girl)*

There were a few positive and negative references to particular aspects of the curriculum. There was only one positive reference to physics topics (from a boy), and 5 negative ones (all from girls and 4 of them from the same school),

> *3093 *Fun but I like doing stuff were you light up lites try and turn them off one so the others stay. (Boy)*

> *662 *At secondary school we do more interesting experiments, the only experiments we did in primary school was about electricity and was boring. (Girl)*

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Chemistry comments	Primary N=313		Secondary N=357	
	n	%	n	%
Chemicals	255	81.47	129	36.13
Chemistry	58	18.53	228	63.87

There were 4 positive references to biology (all from girls in the same school) and no negative references.

> *2021 *In junior school we did not do very much science. We did quite a bit of biology in year six and a little work on physics, but did not cover chemistry. At [X] I really enjoy science especially biology as I like animals and the environment. Chemistry is good too because I like making solutions and heating things with bunsen burners. Although I like science I find physics boring. (Girl)*

However, 120 of the references to chemistry were positive, and there were no negative references. The examples below are typical,

> *175 *We did not do much science in my old school, the science we did do was not very interesting, we never did experiments with chemistry equipment but we do now and I am glad we do. I never used to understand the experiments and it was hard when I had to write up the experiments. (Girl)*

> *1941 *We do more exciting experiments like chemistry. It is more fun doing science in a secondary school. (Boy)*

These results could indicate that 'chemistry' topics were not often taught at primary school, or that they were taught in a very different way from at secondary school, or that children had a particular image of chemistry, which made it special enough to deserve mention. For example, the boy who wrote the comment below says that he has never done chemistry:

> *2396 *We wont have as much help as we do at the moment. We will we doing science with dangerous things. We will be doing chemistry that we have never done before. We will have to do lots of science next year. (Boy)*

Perhaps chemistry does have a special meaning to these children, perhaps it seems less abstract: in chemistry the children suggest that they can 'see what happens' but in physics and, to some extent in biology, this appears not to be the case, as is suggested by the next example:

**2394 Science in secondary school has more experiments. We talk about our ideas as a class (thats still the same). Our last class in my old school did more things about electricity than secondary school. In secondary school we do more experiments so that we can really see what things are happening.*

The National Curriculum aimed to introduce a broad and balanced science course into primary school, which would continue through secondary school. This group of children have experienced National Curriculum science throughout their school career and they demonstrate great awareness of the curriculum, commenting frequently on similarities and differences in the topics that they have met at primary and secondary school, in this respect these findings are similar to those of Hawkey and Clay (1998) and also to those of Morrison (2000) who indicated in a small recent study that *'National Curriculum subjects were rarely commented upon as being different'*. However, since the pupils appear to have a special interest in chemistry, which they regard as a new subject, this would seem to be an area of the curriculum requiring particular attention.

6.3 Gender differences

Both boys and girls expressed positive feelings more often once they were at secondary school (Table 6-22, overleaf). However, although boys and girls made similar proportions of positive comments about science at primary school, girls made considerably more positive comments than boys after transfer.

Table 6-22: Positive words used by boys and girls about science

Positive views	Primary Boys		Secondary Boys		Primary Girls		Secondary Girls	
	n=867	%	n=754	%	n=863	%	n=829	%
Good	17	1.96	16	2.12	13	1.51	18	2.17
Exciting	49	5.65	32	4.24	45	5.21	40	4.83
Interesting	42	4.84	38	5.04	50	5.79	103	12.42
Looking forward/prefer sec	5	0.58	7	0.93	11	1.27	23	2.77
Enjoy	22	2.54	40	5.31	29	3.36	66	7.96
Like	26	3.00	45	5.97	30	3.48	81	9.77
Fun	52	6.00	51	6.76	46	5.33	60	7.24
Brill	2	0.23	2	0.27	1	0.12	5	0.60
Bad in primary	0	0.00	32	4.24	3	0.35	44	5.31
All positive responses	215	24.80	263	34.88	228	26.42	440	53.08
Positive responses per person	179	20.65	217	28.78	189	21.90	289	34.86

So it is possible that after transfer many girls feel much more positive about science, as is typified by the responses of these two girls,

*402 _Primary school response_

It will be harder; we will use computers; we will have more space; we will have less people working at one time; we will have more equipment; we will be working with different things.

*402 _Secondary school response_

Hardly anything is the same, we never did experiments. I enjoy secondary school science much more than I did and I understand science more. I have a wider view of science. I have learned more in one half term than I did in my whole time at junior school. I never used to like science but I love it now. (Girl)

*2731 _Primary school response_

I think that we will do our own experiments a bit more and we might use text books. I think there will be one teacher who maybe helps us and explains what to do.

*2731 _Secondary school response_

I think science is brilliant compared to my primary school, I enjoy all the things that we do. I learn something every lesson, I also think I learn a lot more from this teacher. Different; experiments, equipment, way in which I learn. (Girl)

These observations do not conform to the widely held view that boys are more positive than girls about science (for example, Hadden, 1981; Power, 1981; Francis, 2000). However, some small studies have suggested that girls' enjoyment of science is similar to that of boys (Breakwell and Beardsell, 1992; Woodward &

Woodward, 1998; McMahon, 1999), so the evidence at this point is not clear-cut. Furthermore, many children may be making positive comments about practical work in preference to making a negative statement, this might apply to girls more than to boys (Rickards et al, 1997).

When negative comments were considered, a different picture emerged (Table 6-23). Although the proportion of negative comment was very low at both primary and secondary level, boys made the smaller proportion of negative comments before and after transfer

Table 6-23: Negative words used by boys and girls about science

Negative views	Primary boys		Secondary boys		Primary girls		Secondary girls	
	n=867	%	n=754	%	n=863	%	n=829	%
So-so	0	0.00	0	0.00	0	0.00	2	0.24
Don't like	0	0.00	9	1.19	1	0.12	12	1.45
Not fun	1	0.12	1	0.13	2	0.23	4	0.48
Not good	1	0.12	0	0.00	1	0.12	5	0.60
Bad in secondary	6	0.69	14	1.86	9	1.04	26	3.14
All negative comments	8	0.92	24	3.18	13	1.51	49	5.91
Negative responses per person	8	0.92	11	1.46	12	1.39	28	3.38

These comments, when considered in isolation, suggest that more girls have less positive views about science than boys, and that the number of girls holding such views may increase on transfer.

When the text of the negative responses in Table 6-23 was read, boys and girls appeared to have different reasons for their dislike of science. Boys disliked science if there was less practical work than they had expected and they also disliked writing. Although many girls mentioned lack of practical work as a reason for their dislike of science, there were also quite a few references to people; being separated from friends and dislike of teachers were mentioned. The following are typical examples:

**1414 I think it is more boring in science at secondary school, we have used the bunsen burner once and have never used acid here. (Boy)*

*866 *It's better in that we do lot's more experiments but it's boring writing them up. we still have to write them up like in the Juniors but the experiments are more enjoyable and we do more. (Boy)*

*1402 *Things that have changed; We use more interesting things like, microscopes, test tubes and bunsen burners. Also things have got complicated. Things that haven't changed; I do not really enjoy science that much (Girl)*

*1118 *I suppose the thing that least makes me want to go to science is the teacher. I mean he is exelent at teaching and everything, but I feel he needs to trust us a bit more. (Girl)*

Text associated with the words "better" and "harder" at secondary school seems to corroborate this suggestion of gender differences in the reasons for both negative and positive views. A search for "better" revealed that many boys *and* girls expressed the view that science was better at secondary school. However, boys expressed this view to a much greater extent than the girls, as Table 6-25 shows. Boys were also less likely than girls to use the word 'harder'; Jarman (1993) also observed that girls were more likely than boys to say that secondary science was harder than primary science.

Table 6-24: The use of the words "better" and "harder" to describe science

	Secondary boys N=754		**Secondary girls N=829**	
	n	%	n	%
Better	240	31.83	195	23.52
Will be harder	340	45.09	417	50.30
Is harder	88	11.67	144	17.37
Harder but better	29	3.85	33	3.98

When the text was examined it was apparent that the boys tended to associate the word "better" with experimental work and scientific equipment, as this typical example shows,

*896 *Science is alot better at high school as we do more experiments and use better equipment. In Junior school we only done few experiments which were enjoyable. 7/10 for good experiments at high school.* (Boy)

However, girls appeared to have different reasons for finding science "better" at secondary school, typically mentioning greater interest and better understanding (in addition to comments about equipment and experimental work), as this comment illustrates,

> *2115 *I think that science at secondary school is better because its more interesting and you get to use better equipment. Also I think its explained better (Girl)*

Such differences suggest that the large number of boys making positive comments about science at secondary school may have done so mainly because of the changes in the amount of specialised equipment and laboratory work.

However, where girls said that science was enjoyed or better at secondary school this probably reflected the view that science was more interesting and that more learning could take place; practical work may have been a secondary consideration.

The use of the word "harder" was also helpful in revealing differences between boys and girls; at primary school fewer boys than girls said that they expected science to be difficult, and once at secondary school fewer boys also said that they felt science was difficult. So girls may be more likely than boys to regard science as difficult. However, although more girls said that science was harder at secondary school, some of these girls said that it was better *because* it was harder. Suggesting an enjoyment of challenge. For example:

> *1636 *Secondary school science is much harder, and that makes it more exciting, I like it much more. (Girl)*

A similar proportion of boys used the words harder and better, but the context was different; science was harder, but it was also better because of the experiments and equipment, as the following example illustrates:

> **2373 We get a lot more homework and it is quite a lot harder than primary school. I like it better here because the experiments are a lot more interesting. It was more easier in primary school but its better hier. (Boy)*

In addition, girls referred more often to understanding and autonomy than did boys (Table 6-25), again suggesting that these aspects were particularly important to them.

Table 6-25: A comparison of references to autonomy or understanding or knowledge by boys and girls

	Secondary boys N=754		**Secondary girls N=829**	
	n	%	n	%
Autonomy	76	10.08	132	15.92
Understanding/knowledge	86	11.41	140	16.89

To summarise, girls and boys may have different reasons for their attitudes to science, boys probably enjoy science because of the practical work, but girls may enjoy it because of improvements in learning, understanding and possibly independence.

The proportions of comments about most aspects of the facilities are similar for boys and girls (Table 6-26); but more girls than boys at both primary and secondary school referred to experiments, equipment and computers.

Table 6-26: A comparison of words used to describe science facilities by boys and girls

	Primary Boys		**Primary Girls**		**Secondary Boys**		**Secondary Girls**	
	n=867	%	n=863	%	n=754	%	n=829	%
Experiments	204	23.53	263	30.48	332	44.03	482	58.14
Equipment (general)	257	29.64	266	30.82	284	37.67	315	38.00
Computers	156	17.99	178	20.63	29	3.85	41	4.95
Laboratories	76	8.77	72	8.34	27	3.58	33	3.98
Books	50	5.77	74	8.57	37	4.91	45	5.43
Bunsen burners	66	7.61	37	4.29	131	17.37	137	16.53

An examination of words associated with the references to experiments does not suggest any great differences in the attitudes of boys and girls towards practical work (Table 6-27). However, boys make slightly more positive comments at primary school, and at secondary school more boys use the word "better" to describe experiments.

Table 6-27: Words associated with the word "experiments" by boys and girls

	Primary Boys		Primary Girls		Secondary Boys		Secondary Girls	
	n=867	%	n=863	%	n=754	%	n=829	%
More	117	13.49	129	14.95	159	21.09	169	20.39
Harder	46	5.31	68	7.88	18	2.39	17	2.05
Positive comments	44	5.07	30	3.48	82	10.88	86	10.37
Better	20	2.31	10	1.16	39	5.17	24	2.90
Own	10	1.15	14	1.62	13	1.72	14	1.69
Dangerous	7	0.81	5	0.58	7	0.93	4	0.48
Boring	0	0.00	0	0.00	6	0.80	6	0.72
Writing up	0	0.00	4	0.46	18	2.39	35	4.22

These differences suggest that boys may take a more positive view of practical work, and perhaps find science 'better' and less difficult than girls. On the other hand, the large overall increase in references to experiments by girls (Table 6-26) from 31% to 58%, compared with the increase by boys from 24% to 44% suggests that girls may become more positive about practical work than boys, on transfer to secondary school. Furthermore, girls refer to greater autonomy and improved understanding in positive terms, suggesting that they enjoy science more because of these aspects. So these written responses perhaps offer limited support for the view that boys are more positive than girls about science, but the relative proportions of positive responses suggest that there may be a group of girls who are more positive about science than are boys.

Another way of resolving this issue of gender differences may be to look at features mentioned by boys and girls in connection with practical work. In particular: bunsen burners, dissection and danger, which Measor and Woods (1984) have associated with gender. However, the current research finds that responses concerning these aspects are few, and that gender differences appear to be limited (see Table 6-28, below).

Table 6-28: References to Bunsens, dissection, excitement or danger by gender

	Primary Boys		Primary Girls		Secondary Boys		Secondary Girls	
	n=867	%	n=863	%	n=754	%	n=829	%
Bunsen burners	66	7.61	37	4.29	131	17.37	137	16.53
Dissection	24	2.77	29	3.36	0	0.00	2	0.24
Exciting/dangerous	16	1.85	5	0.58	7	0.93	8	0.97

Boys have more to say about bunsen burners at primary school, but after transfer there is little difference between the proportions of comments by boys and girls. References to bunsen burners are sometimes found in connection with excitement and danger, boys making the majority of such references. However, these remarks are few in number and the majority occur at primary school before any experience with bunsen burners. There was no evidence from the tone of the written comments about bunsen burners to indicate any gender differences; both boys and girls seemed to enjoy opportunities to use them.

Interviews did not illuminate these differences either. Both boys and girls were asked how they felt about using Bunsen burners, although many said that they had been nervous initially, by the time of the interview (halfway through their second term) all were quite confident about their use. Here are two typical responses,

> *Girl: ...at first I was nervous about using the bunsen burner... but the bunsen's OK now.*
>
> *Boy: ... The first time I used it I though it would blow up in my face, I was nervous to start with.*

Similar number of boys and girls at primary school expected that dissection would be part of secondary school science.

Only 4 children expressed any negative feelings about this (3 girls and 1 boy).

> **377 More people will be there and we cut animals open. We do some dangerous experiments and there is a science club in [secondary school]. There will also be more equipment so it might be a bit more fun. I think that we should not kill animals to do experiments, we should wait till they die (Boy)*

> *3218 *Next year we will be able to do much more things when we go up to the secondary school. We will be allowed to open up animals which I don't think I'm going to like very much but I think I'm going to enjoy science in secondary school. (Girl)*

There were only two references to dissection at secondary school, both from girls; neither seemed concerned at the prospect of dissection work:

> *1844 *In secondary school we get do experiments. In junior school a teacher showed us the inside of a lambs heart and named the parts inside, but i'm sure we will get to do something similar soon. (Girl)*

> *1223 *I don't like science at all, it's my worst subject EVER because it is boring.I thought we would be disecting stuff, but we haven't. Science was better at my old school. (Girl)*

There is little evidence within this data to support any idea of gender differences; more girls than boys referred to dissection at primary school (24 boys and 29 girls), but the difference in numbers is not convincing. However, there were clusters of comments from children transferring to particular secondary schools (see Appendix 6). These observations suggest that ideas about dissection might come from the schools themselves, and interviews with individual children tended to support this view. Children who said in interview that they expected to dissect animals at secondary school, mentioned two sources of information: in a few cases the source was older siblings and other relatives, but the most common source was open events at secondary schools where there were demonstrations of dissections. Perhaps false expectations about secondary science are being raised by such events.

So, in the present research, the evidence from the children's own writing does not seem to indicate that boys are more positive about science than girls; this is in contrast to much of the literature discussed in Chapter 2 (page 83). However, the majority of those studies were quantitative studies, and most did not control for social influences or attitudes to school; those finding no difference had included controls (Breakwell and Beardesell, 1992). However, qualitative studies, with small groups in single schools, suggested few gender differences (Collins, 1993; McMahon, 1999). So, it seems possible that gender alone is not an important variable, but that gender within a particular social setting may be important. Arnot et al (1999) make the same point,

> *Thus the real question is not whether girls as a group or boys as a group are more disadvantaged, but which girls and which boys (Teese et al, 1995: 109)* (cited in Arnot et al,1999 p. 29).

6.4 Socio-economic differences

The results of this study have suggested that gender alone is far too broad a categorisation, so the positive and negative references were next categorised by the proportion of free school meals (FSM) taken by the schools, as well as gender (see Table 6-29, below).

Table 6-29: Positive words used at secondary schools grouped by gender and FSM

	Girls						Boys					
	Low FSM		Average FSM		High FSM		Low FSM		Average FSM		High FSM	
	n=282	%	n= 272	%	n=271	%	n= 267	%	n= 247	%	n=232	%
Good	19	6.74	7	2.57	5	1.85	7	2.62	9	3.64	16	6.90
Exciting	43	15.25	22	8.09	20	7.38	38	14.23	21	8.50	22	9.48
Interesting	55	19.50	52	19.12	46	16.97	26	9.74	27	10.93	27	11.64
Enjoy	51	18.09	20	7.35	24	8.86	34	12.73	12	4.86	16	6.90
Look forward to	13	4.61	12	4.41	9	3.32	5	1.87	4	1.62	3	1.29
Brill	4	1.42	0	0.00	2	0.74	1	0.37	3	1.21	0	0.00
Fun	58	20.57	31	11.40	17	6.27	43	16.10	37	14.98	22	9.48
Like	55	19.50	31	11.40	25	9.23	25	9.36	18	7.29	28	12.07
Prefer secondary	5	1.77	9	3.31	3	1.11	1	0.37	2	0.81	1	0.43
Was bad in primary school	20	7.09	19	6.99	11	4.06	15	5.62	10	4.05	7	3.02
Positive responses per person	125	44.33	101	37.13	63	23.25	92	34.46	67	27.13	58	25.00

When the responses were categorised in this way there was a large difference in the proportions of positive words used by boys and girls in areas where there was little social deprivation, girls making the larger proportion (44%). However, where social deprivation was high the difference between the positive words used by boys and girls was small. The table also shows that the highest proportion of girls with positive feelings was from the low FSM group and that fewer girls from the high FSM group had positive feelings about science. The same was true for boys, although the range was narrower.

This data suggests that girls from more prosperous backgrounds may be breaking free from the traditional gendered views discussed in Chapter 2 (page 86), whereas those from poorer background may be conforming to gender stereotypes.

Girls in high FSM schools who made positive comments were quite cautious in their praise of secondary science, rarely using very positive words. The use of the words "interesting" and "like" were more usual than words such as "enjoy" or "exciting" for example,

> *2945 *I don't think anything is the same except the experiments, in [X] you have proper equipment and we do good experiments, we also use computers in [X] we never used computers in Junior School. I also found science boring in the Junior school, but now it lightend up in [X]. (Girl)*

> *3002 *Science is more interesting at senior school. (Girl)*

However, girls in low FSM schools made use of very positive words to express their feelings, for example,

> *894 *Science in the junior school was boring when you compare it with this years work. You get to use more interesting Equipment like Acids and Bunson Burners, you even get to make your own water filter. It is a lot of fun!!!! (Girl)*

> *1759 *We hardly did Science at our last school, and I think Science now is fantastic. (Girl)*

These findings tend to suggest that girls' views of science may be related to their social background. Negative views about science being most deeply embedded and difficult to change for those with lower SES.

Boys from high FSM schools also tended to make more use of 'interesting' and 'like', but additionally they made more use of the words 'exciting' and 'fun' to link their enjoyment with practical work, for example,

*3297 *There is quite a difference, but if it was to compare I would say science at secondary school is better because we do exciting experiments. (Boy)*

*21 *In our old school we did do some things like magnets but in this school we do an experiment every lesson and we have more time in this school. We can use bunsen burners and things like that and chemicals it is quite fun. (Boy)*

When negative words were categorised in the same way, girls made far more negative comments than boys and girls from areas of low social deprivation made the largest proportion of negative comments. Whereas boys from the lowest FSM schools made the smallest proportion of negative responses and those from high FSM schools made the greatest proportion (Table 6-30).

Table 6-30: Negative words used at secondary schools grouped by gender & FSM

	Girls FSM						Boys FSM					
	Low		Average		High FSM		Low		Average		High	
	n=282	%	n= 272	%	n=271	%	n= 267	%	n= 247	%	n=232	%
Worried	1	0.35	2	0.74	2	0.74	0	0.00	0	0.00	0	0.00
Don't like	5	1.77	1	0.37	3	1.11	1	0.37	2	0.81	1	0.43
Not fun	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Not good	1	0.35	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Boring	9	3.19	4	1.47	6	2.21	1	0.37	1	0.40	2	0.86
All negative words	12	4.26	7	2.57	8	2.95	3	1.12	4	1.62	4	1.72

However, girls who expressed negative feelings tended to moderate these with additional references to the improved nature of science at secondary school.

*1402 *Things that have changed; We use more interesting things like, microscopes, test tubes and bunsen burners. Also things have got complicated. Things that haven't changed; I do not really enjoy science that much.* (Girl high FSM)

**233 Even though it's not my favorite of all subjects, I have to admit it's more fun because we always used to do writing. We've still have to do loads of writing though we've only ever used the computers once and for only a little while. We use more equipment, I still don't look forward to it though! One other thing is that the more experiments we do, the more writing there is afterwards!! I still think it's quite boring and it hasn't changed. (Girl low FSM)*

As these comments show, the girls' negative responses did not really throw much light on their dislike of science. In contrast, although it was rare to find negative comments by boys, where they did occur there were clear indications that repeated work might have been the cause of their negative views,

**692 We hardly did science at school last year, we only did about lighting light bulbs. Some of the science I do is fun and some is boring, and stuff about what I know. (Boy average FSM)*

**3105 Science last year wasn't very often. we did work on forces and that was about it. We didn't do experiments with bunsen burners or any thing like that. We just did writing and drew pictures. The work can some times be similar to not just last year, but other years in science so I some times get bored. (Boy low FSM)*

It has been suggested that negative feelings about science may be related to the difficulty of the subject (Johnstone, 1991; Millar, 1991) so perhaps girls' dislike of science may be related to its perceived difficulty, as suggested by Watson et al (1994). Responses concerning the difficulty of science are shown in Table 6-31 below.

Table 6-31: Feelings about the difficulty of science at secondary school grouped by gender & FSM

	Girls						Boys					
	Low FSM		Average FSM		High FSM		Low FSM		Average FSM		High FSM	
	n=282	%	n= 272	%	n=271	%	n= 267	%	n= 247	%	n=232	%
Will be easier at secondary	0	0.00	0	0.00	0	0.00	0	0.00	1	0.4	0	0.0
Easier at secondary	6	2.1	1	0.4	0	0.00	5	1.9	3	1.2	3	1.3
Will be harder at secondary	138	48.9	129	47.4	153	56.5	128	47.9	92	37.3	123	53.0
Harder at secondary	38	13.5	39	14.3	51	18.8	26	9.7	29	11.7	19	8.2
Harder but better at secondary	18	6.4	17	6.3	9	3.3	10	3.8	15	6.1	10	4.3

Only one pupil, a boy, expected science to be easier at secondary school, and a few boys and girls found it easier than anticipated once at secondary school. However, a large number of children expected science to be harder at secondary school, and more children from schools with highest FSM were inclined to expect science to be difficult. Many of these children did not comment on the difficulty of science once at secondary school, suggesting that their concerns about difficulty might have been unfounded. However, where difficulty was commented upon, the greater proportion of comment came from girls. So it is possible that girls' dislike of science is linked with perceptions of difficulty. There was also a clear trend for girls; as the proportion of FSM increased so did the proportion of responses about science being harder at secondary school, suggesting that perceptions of difficulty were more common among girls from schools with higher FSM. However, many of the girls in high FSM schools said that science was more interesting because it was harder. The following examples are typical of the remarks made by girls:

> *3119 *I like it more, we do harder things, we use better things and we have a proper science teacher. (Girl Low FSM school)*
>
> *2279 *Science at secondary school is more intresting than science at primary school because it is more harder. (Girl High FSM school)*

No trend was apparent for boys, but the lowest proportion of responses about the difficulty of science came from boys in schools with the highest proportion of FSM, suggesting that perceptions of difficulty might have a different meaning for boys. Boys tended *not* to link difficulty with interest, preferring to follow references to difficulty with comments about excitement or practical work. The following are typical examples of their responses:

> *2609 *Things are different because it gets harder and we go into more detail. I enjoy it more because theres better equipment. (Boy High FSM school)*

**1987 Science is a lot harder in secondary school than in Junior School. It is a lot more exiting! (Boy High FSM school)*

Girls appear to be more likely than boys to link science with difficulty, but also more likely to link difficulty with interest; and this applies across all socio-economic groups. However, girls from poorer backgrounds seem the most likely to hold negative views about science, as suggested in the literature (Bentley reported in Hofkins, 1996; Wikeley & Stables, 1999; and 2000), but girls from more affluent backgrounds are the most likely to hold positive views. These findings suggest that girls from more affluent backgrounds may have overcome the traditional gender stereotypes associated with science described in the literature (for example, Ormerod, 1976; Measor & Woods, 1984; Riddell, 1992; Elwood & Gipps, 1999). Similar trends are much less clear-cut for boys, indicating that their social background was not particularly relevant to their enjoyment of science; this may be because the masculine nature of science corresponded with their own identities. Other factors, such as the greater use of practical work were more important to boys.

Therefore, differences in attitudes to science might be related to both gender and socio-economic background; this idea is supported to some extent by the literature (Fenemma, 1996; Arnot et al 1999).

6.5 Summary

A large proportion of the children were positive about secondary science, and in this area the children's written comments supported the quantitative data. But there were relatively few negative remarks in comparison with the quantitative data. It seems probable that the low number of negative comments could result from children choosing to make positive statements about practical work, rather than making a negative comment about science lessons in general.

The tone and number of the comments made, suggests that the majority of these children regard secondary science as better than primary science because of the experimental work, the specialist equipment and the specialist teaching. These children felt that having a specialist teacher in science was a positive advantage; the focus was on clearer explanations and on being allowed to do things themselves. These children enjoyed experimental work because it allowed them to move about instead of having to 'sit around and watch' and it also produced feelings of greater autonomy. There was a very small group of children who said that primary science was better than secondary science. They spoke of secondary science lacking clarity in explanations and as being harder than at primary school; they also felt that their role in science lessons was too passive. The quality of teaching seems to be very important for these children, and on balance the feeling seemed to be that on transfer the teaching had changed for the better as well as the facilities.

Children in primary school expected secondary school work to be harder, but seem to have found it less difficult than expected after transfer. A small number of children expressed anxieties and fears, but the decline in such comments after transfer suggests that most children had adjusted quite well to secondary science. Very few primary school children expected work to be repeated at secondary school. However, at secondary school a substantial number of children referred to repeated work, but most of these did not seem de-motivated by the experience, in fact they seemed quite pleased that they knew something about the topic under discussion.

It seems possible that an important change in attitude has taken place on transfer. Once at secondary school, many children denied having done science at primary school, or said that primary science was not interesting, not enjoyable, and not science. These children demonstrate great awareness of the science curriculum, commenting frequently on similarities and differences in the topics that they have met at primary and secondary school. The relatively large number of references to similarities in physics and biology, and the lack of any references to differences suggest that physics and biology may have been extensively covered at primary school. In contrast, chemistry is a subject that may have received relatively little attention in primary school.

Boys made less positive comments and less negative comments about science than girls at both primary and secondary school. The differences in the content of positive comments by boys and girls suggest that boys may take a more positive view of practical work, and perhaps find science 'better' and less 'hard' than girls. On the other hand, the large overall increase in references to experiments by girls on transfer to secondary school suggests that girls may become more positive about practical work. Furthermore, girls refer to greater autonomy and improved understanding in positive terms, suggesting that they enjoy science more because of these aspects.

The findings suggest that girls' views of science may be related to their social background. Negative views about science seemed most deeply embedded and difficult to change for children from less affluent areas. Children from schools with highest FSM were more inclined to expect science to be difficult. For boys, social background did not seem to be particularly relevant to their enjoyment of science - the greater use of practical work was more important. Girls from poorer backgrounds seem the most likely to hold negative views about science, suggesting that girls from more affluent backgrounds have overcome the traditional gender stereotypes associated with science. The status and stereotyping associated with science may be working against the expectations of children from more deprived backgrounds.

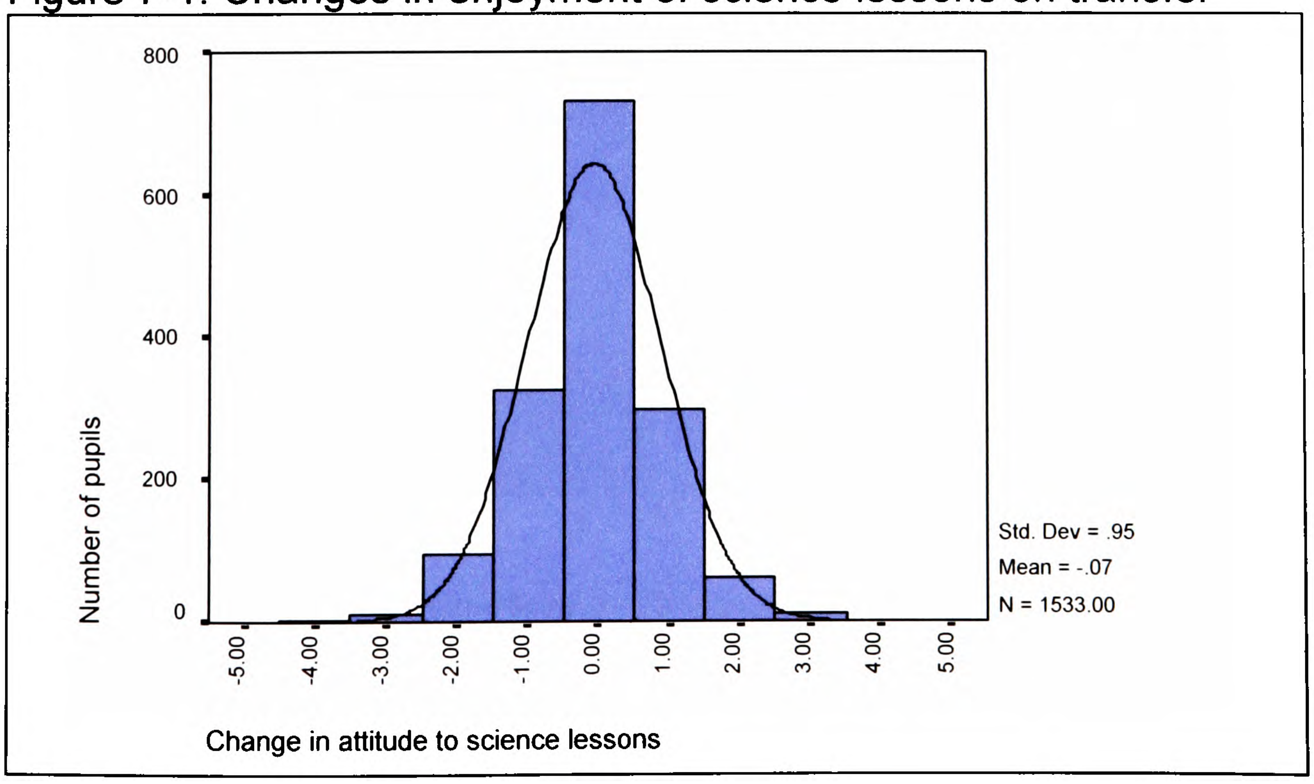
CHAPTER 7. CHANGES IN ATTITUDES ON TRANSFER.

In this Chapter the results of the analyses of the change data are described and discussed, and the important factors associated with changes in attitudes on transfer from primary to secondary school are identified. First, the individual changes in attitudes are shown using simple histograms, and then correlation and regression analyses are used to reveal significant relationships.

7.1 The observed changes in the scores on attitude sub-scales

The suggestion, in the literature, of a *general* decline in enjoyment of science on transfer is not supported by the longitudinal analysis in this research. The present study demonstrates that although some children enjoy science less after transfer, the majority become either more positive or remain unchanged on transfer. The change data are given in full in Appendix 7, but, for ease of reading, summary histograms and bar charts are presented in this Chapter. Figure 7-1 reveals that, although many children (47%) did become less positive about science after transfer, a large number of children became *more positive* (39%).

Figure 7-1: Changes in enjoyment of science lessons on transfer



Thus, it would be wrong to suggest a wholesale decline in enjoyment of science, and this finding confirms that of a similar[1] longitudinal analysis (Power, 1981). Similar observations can be made for each of the attitude sub-scales (Figures 7-2 to 7-7) - overall changes in facility of science and difficulty of written work are the same whether cross-sectional or longitudinal data are used[2], but using longitudinal data makes it possible to identify which children find science easier or more difficult.

Figure 7-2: Changes in perceptions of the difficulty of science on transfer

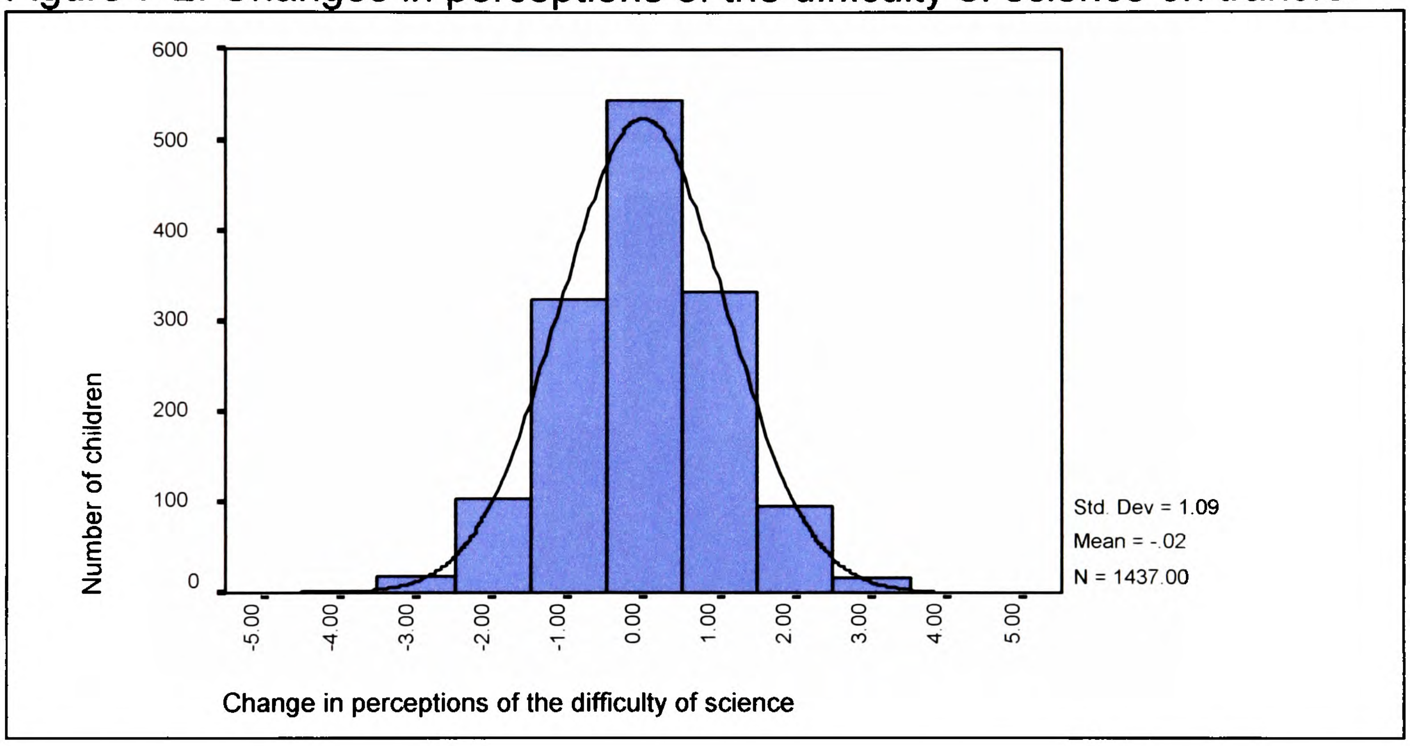
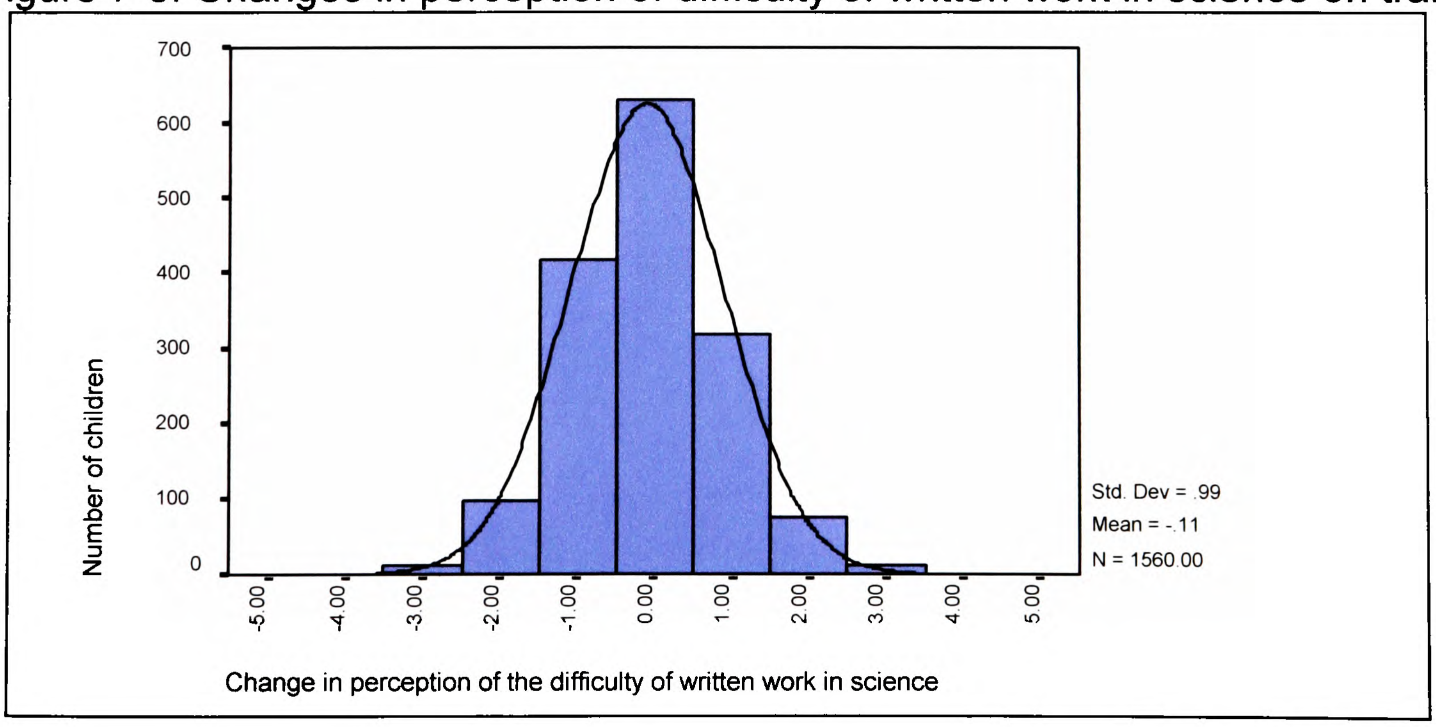


Figure 7-3: Changes in perception of difficulty of written work in science on transfer



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[1] Similar, that is, in its form of analysis.
[2] The cross-sectional data is in Chapter 4

Figure 7-4: Changes in attitudes to using computers in science on transfer

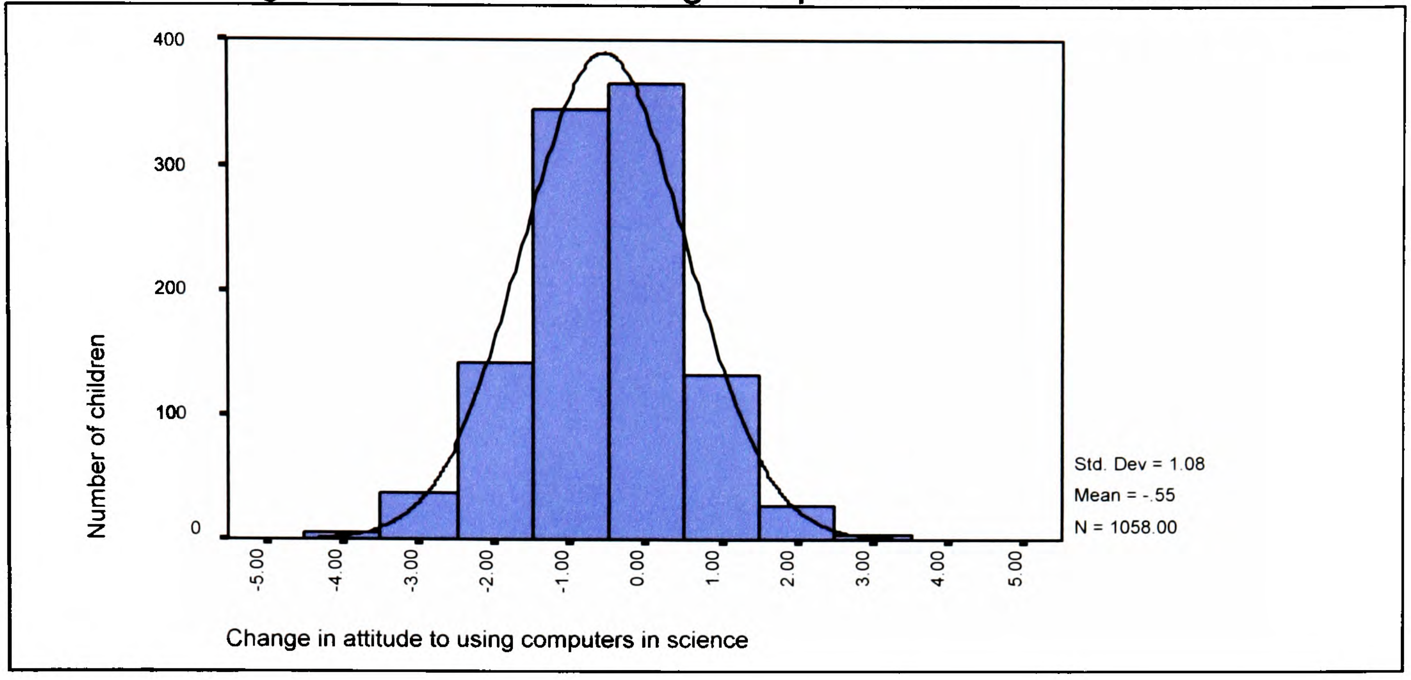


Figure 7-5: Changes in perceptions of continuity and progression on transfer

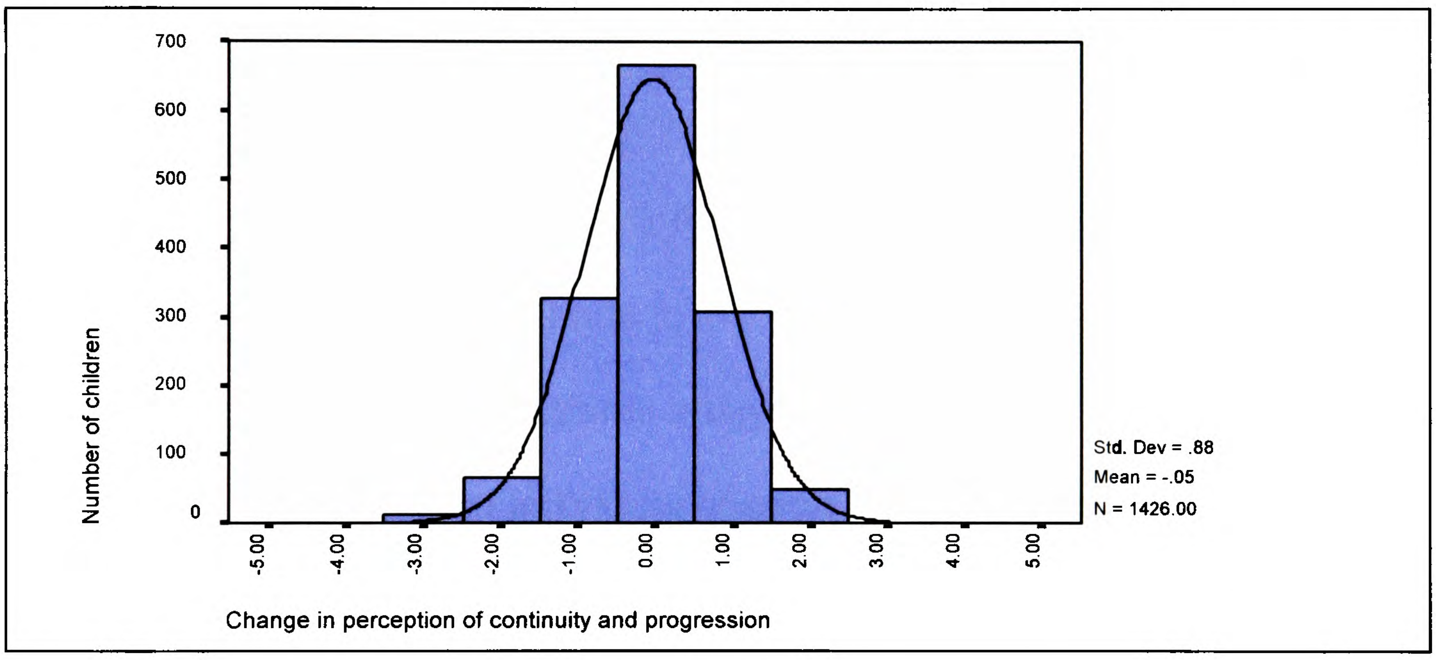


Figure 7-6: Changes in enjoyment of school on transfer

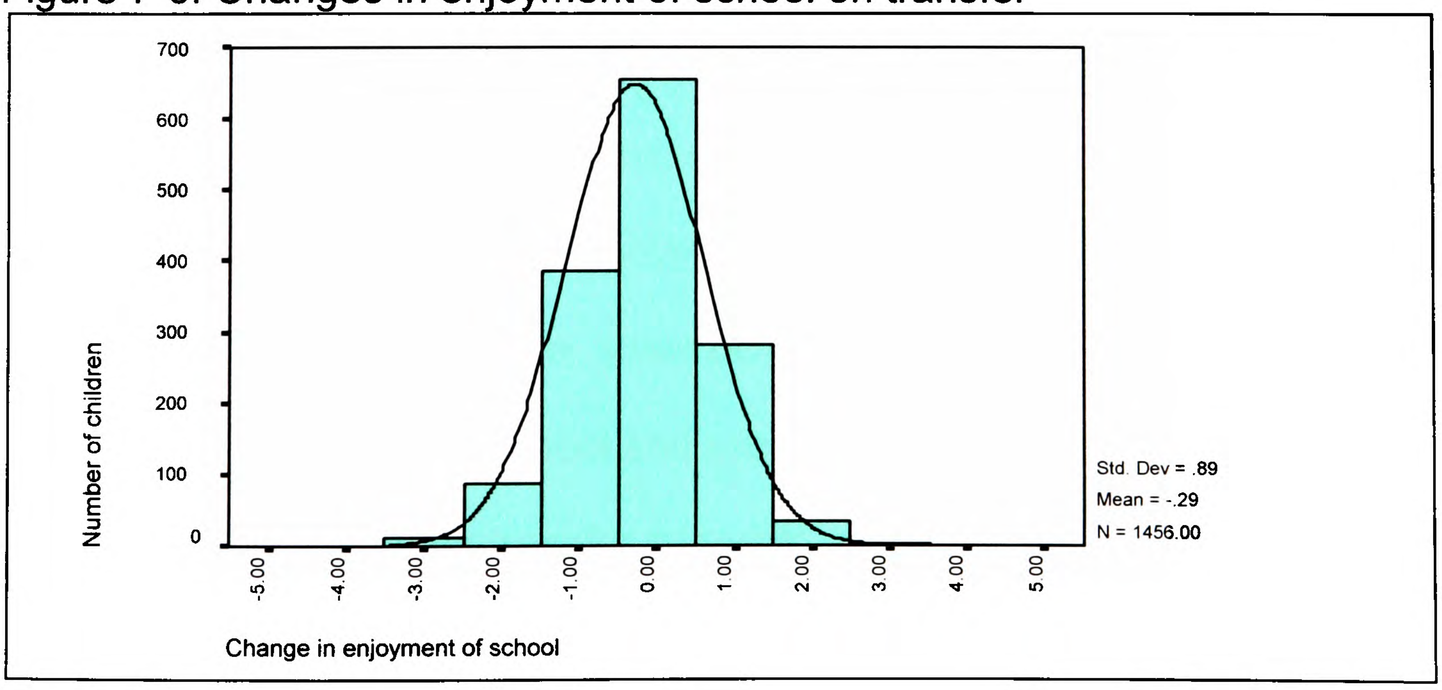
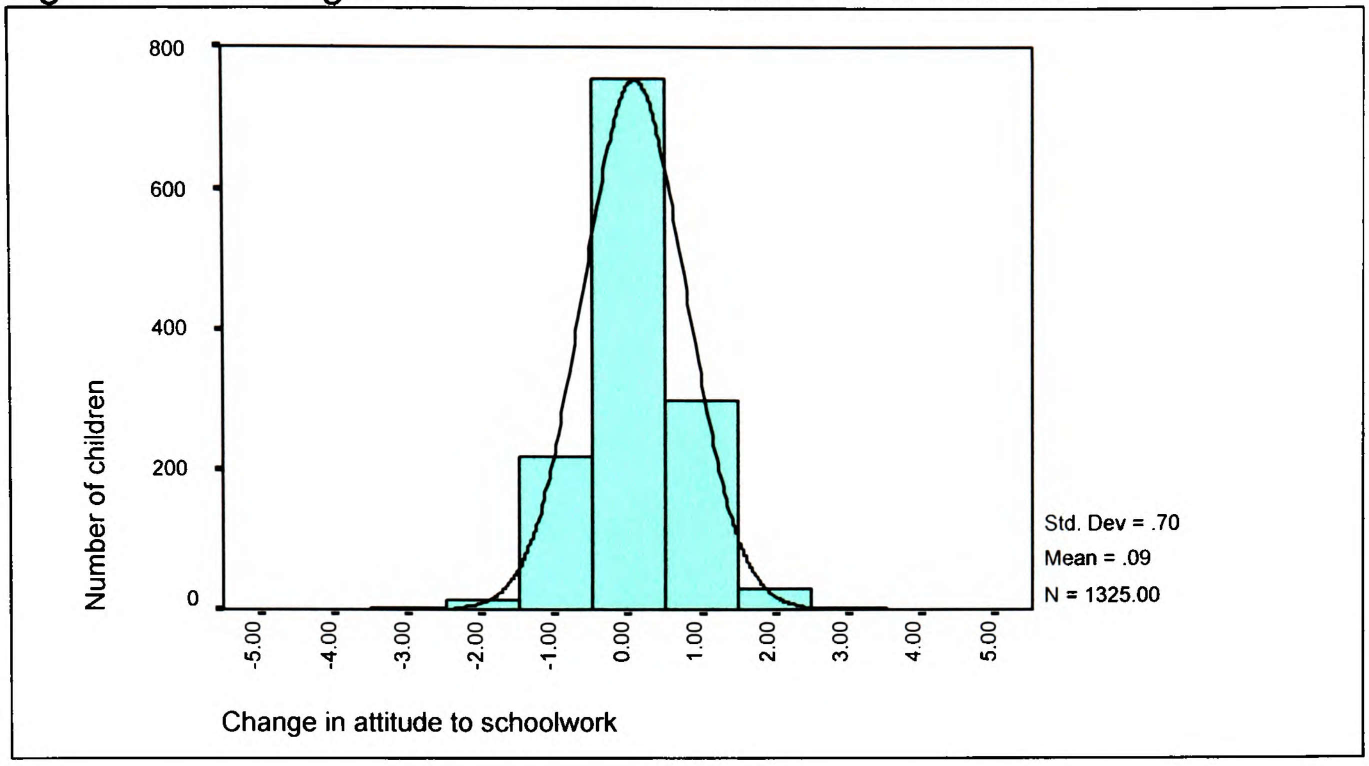


Figure 7-7: Changes in attitude to schoolwork on transfer



So, although both cross-sectional and longitudinal data yield some similar information, (an overall decline in enjoyment of science of 12%), longitudinal analysis offers further useful information not available from cross-sectional analyses. Longitudinal analysis leads to the identification of those individuals who have changed, but the cross-sectional analysis can only speak of the overall decline. Such comparisons of individual change allow a different emphasis to be placed on the analysis. Rather than asking why there was a decline in enjoyment on transfer, a more precise question might be, what factors are involved which lead some children to be more positive while others become less positive?

There is little difference between changes for boys and for girls (Figures 7-8 & 7-9), but boys tend to have more polarised views, leading to longer 'tails' in their frequency tables. In consequence, some boys are more positive about science than are girls at both primary school and secondary school. The apparent lack of change in the gender gap on transfer suggests that any changes in enjoyment of science are unlikely to be linked with gender alone.

Figure 7-8: Changes in enjoyment of science on transfer for boys

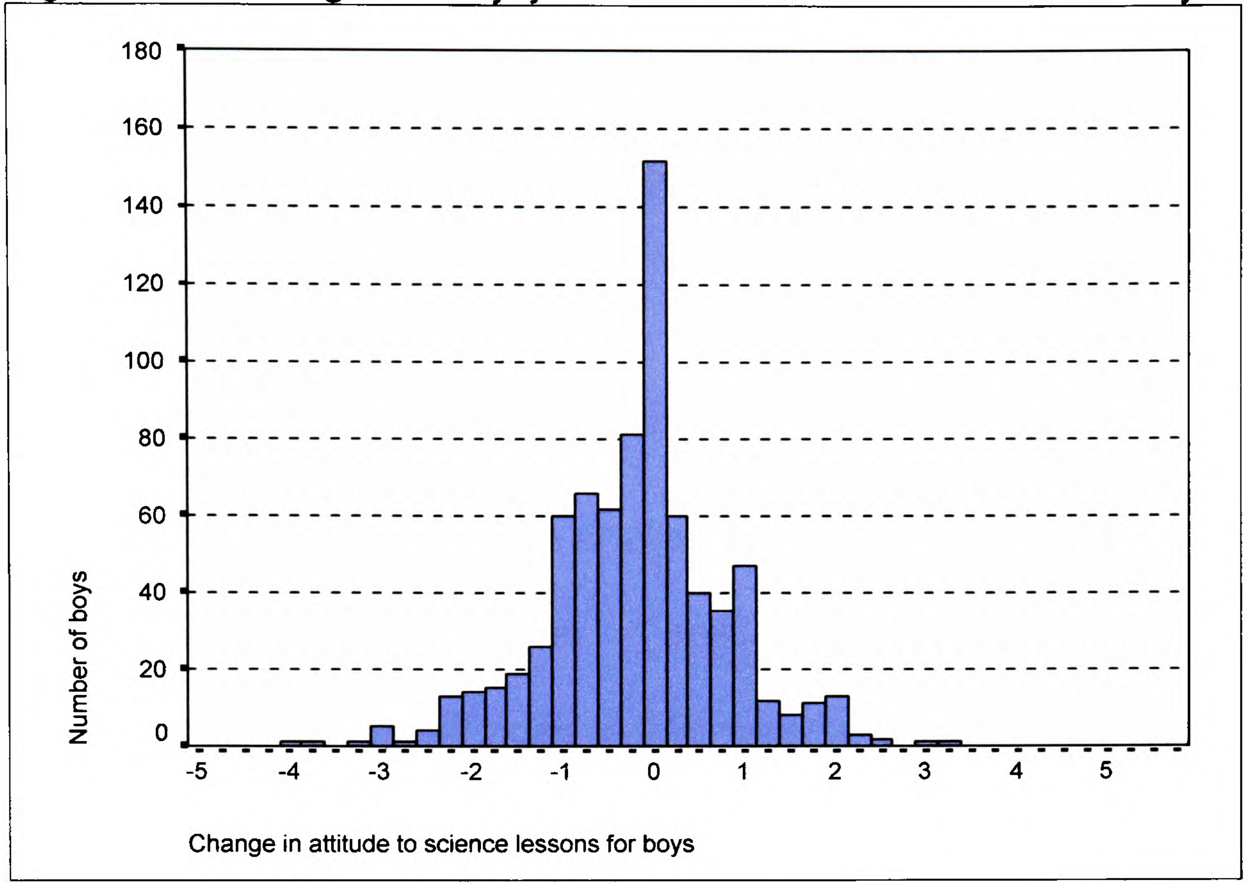
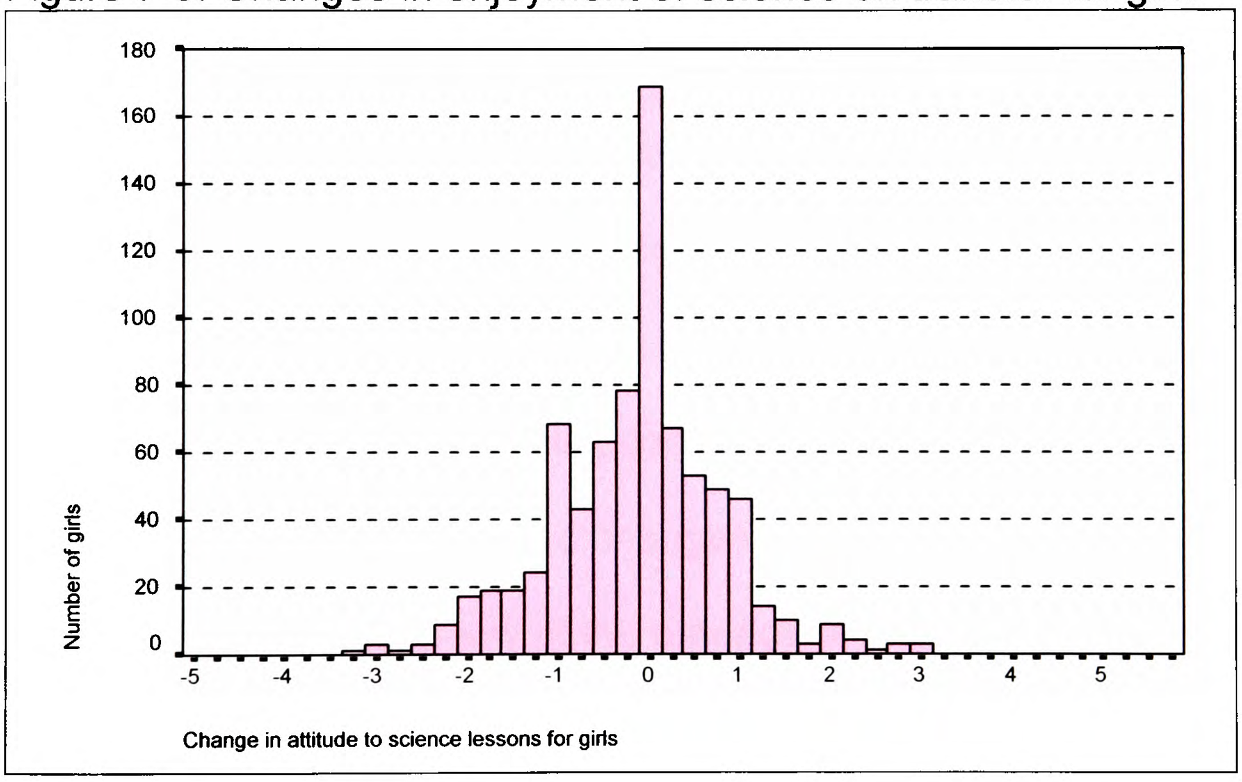


Figure 7-9: Changes in enjoyment of science on transfer for girls



In summary, inspection of the frequency charts for changes in attitude to science supports the findings of the cross-sectional analyses in Chapter 4. Enjoyment of science falls slightly at transfer, there is no change in perception of facility, but written work seems slightly easier. The frequency charts also indicate that overall gender differences seem to be maintained on transfer from primary to secondary school. In addition, these frequency charts provide information not to be had from cross-sectional analysis: the observation that, although the majority of children do not change their attitude to science substantially, there is a group of children whose attitude to science after transfer is much more positive and another group whose attitude is much more negative.

7.2 Discussion of the changes at transition

Changes in children's attitudes were analysed using correlation coefficients and partial correlation coefficients (Tables 7-1 and 7-2). The results for these changes were similar to those for the attitudes to science and school in years 6 and 7 (pages 214 & 216). Calculations of simple bivariate correlations (Table 7-1) showed that changes in attitudes to school (enjoyment of school and attitude to schoolwork) were significantly related to changes in attitudes to science. When the effect of changes in attitudes to school were controlled using partial correlation coefficients (Table 7-2) the changes for three science attitudes (enjoyment, difficulty, and written work) were found to be significantly related to each other. However, changes in attitudes to using computers in science were not related to changes in enjoyment of science and changes in perceptions of continuity and progression were unrelated to any of the other attitude changes.

Table 7-1: The relationships between the changes in attitudes on transfer

	Pearson's correlation coefficients for change in						
	Attitude to schoolwork	**Enjoyment of school**	**Enjoyment of science lessons**	**Difficulty of science**	**Difficulty of science written work**	**Attitude to using computers in science**	**Perception of continuity and progression**
Attitude to schoolwork		0.357**	0.192**	-0.117**	-0.190**	0.102**	-0.031
Enjoyment of school	0.357**		0.336**	-0.367**	-0.259**	-0.058	0.094**
Enjoyment of science lessons	0.192**	0.336**		-0.335**	-0.278**	-0.049	-0.011
Difficulty of science	-0.117**	-0.367**	-0.335**		0.345**	0.153**	0.008
Difficulty of written work in science	-0.190**	-0.259**	-0.278**	0.345**		0.159**	0.038
Attitude to using computers in science	0.102**	-0.058	-0.049	0.153**	0.159**		-0.054
Perception of continuity and progression	-0.031	0.094**	-0.011	0.008	0.038	-0.054	

** Correlation is significant at the 0.001 level (2-tailed).

Table 7-2: The relationships between the changes in attitudes: controlling for changes in attitude to school.

	Partial correlation coefficients for change in:				
	Enjoyment of science	Difficulty of science	Difficulty of written work in science	Attitude to using computers in science	Perception of continuity and progression
Enjoyment of science		-.2441**	-.2031**	-.0431	-.0395
Difficulty of science	-.2441**		.2812**	.1407**	.0473
Difficulty of written work in science	-.2031**	.2812**		.1658**	.0576
Attitude to using computers in science	-.0431	.1407**	.1658**		-.0400
Perception of continuity and progression	-.0395	.0473	.0576	-.0400	

** Correlation is significant at the 0.001 level (2-tailed).

Therefore, as before, a general picture of attitude to science can be built up by considering the three attitude sub-structures (enjoyment, difficulty, and written work), one change in attitude having an effect on each of the others. As Petty (1995) has said:

> *Perhaps the most important implication of viewing attitudes as integrated structures is that if you modify some particular aspect of the attitude structure ... this will likely lead to some change in the overall evaluation of the object (i.e. the attitude) itself, though it may take some time and thought for the change to occur. (Op. cit., p201)*

Consequently, a change in any one of these attitudes is likely to bring about a change in the overall attitude to science, and so the variables affecting these 'changes in science attitude' are discussed together.

The results of the regression analyses with the changes on transfer of the three 'science attitudes' and enjoyment of school as dependent variables, are summarised in Tables 7-3 to 7-12, and the full regression analyses are given in Appendix 8. The following sections are devoted to each of the important groups of variables: gender, attitudes to school, socio-economic status, liaison strategies, pedagogy and teachers' personal views.

Table 7-3: Significant variables for the change in enjoyment of science

Regression block	Predictor variable	R square	R square change	Unstandardized Coefficient B Constant = -0.78
Secondary school	Use of transfer information	0.019	0.019	0.24
	Separate sciences	0.033	0.013	0.39
	Primary teacher assessments available	0.042	0.010	0.17
Secondary teacher	Secondary teachers f2 factor	0.051	0.009	0.07
Change in classroom activity	Change in frequency of collaborative work	0.068	0.017	0.03
Change in attitude to school	Change in enjoyment of school	0.160	0.093	0.33

Table 7-4: Significant variables for the change in boys' enjoyment of science

Regression block	Predictor variable	R square	R square change	Unstandardized Coefficient B Constant = -1.86
Secondary school	One or more A-G grades at GCSE	0.017	0.017	0.019
	Timetabled time available for liaison	0.035	0.018	-0.312
	Separate sciences	0.052	0.017	0.337
Change in classroom activities	Change in frequency of collaborative work	0.078	0.026	0.034
Change in attitudes to school	Change in enjoyment of school	0.152	0.074	0.285

Table 7-5: Significant variables for the change in girls' enjoyment of science

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 0.186
Secondary school	Use of CASE scheme	0.039	0.039	-0.450
Change in attitude to school	Change in enjoyment of school	0.196	0.157	0.422

Table 7-6: Significant variables for the change in difficulty of science writing

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = -0.32
Secondary school	Free school meals %	0.013	0.013	0.01
Change in attitudes to school	Change in enjoyment of school	0.080	0.067	-0.24
	Change in attitude to schoolwork	0.090	0.011	-0.16

Table 7-7: Significant variables for the change in difficulty of science writing for boys

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant =-0.37
Secondary school	Free school meals %	0.024	0.024	0.02
Change in attitudes to school	Change in enjoyment of school	0.107	0.083	-0.24
	Change in attitude to schoolwork	0.132	0.025	-0.22

Table 7-8: Significant variables for the change in difficulty of science writing for girls

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = -0.18
Change in attitudes to school	Change in enjoyment of school	0.051	0.051	-0.26

Table 7-9: Significant variables for the change in the difficulty of science

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 0.30
Secondary school	Use of transfer information	0.013	0.013	-0.22
Secondary teacher	Secondary teachers' process-content score	0.024	0.010	-0.15
Change in classroom activity	Change in frequency of teacher directed work	0.033	0.009	0.03
Change in attitudes to school	Change in enjoyment of school	0.158	0.125	-0.43

Table 7-10: Significant variables for the change in the difficulty of science for boys

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 1.812
Secondary school	Timetabled time available for liaison	0.030	0.030	0.614
	% with five or more A-G grades at GCSE	0.052	0.023	-0.029
	Number of pupils on roll	0.076	0.023	0.000
Change in attitudes to school	Change in enjoyment of school	0.163	0.087	-0.356

Table 7-11: Significant variables for the change in the difficulty of science for girls

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = -.154
Change in attitudes to school	Change in enjoyment of school	.181	.181	-.525

Table 7-12: Significant variables for the change in the enjoyment of school

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = 0.22
Child	Gender	0.009	0.009	-0.13
Primary school	Use of topic approach in primary school	0.019	0.010	-0.13
Secondary school	Number of half day sessions used for induction	0.048	0.029	-0.11

7.2.1 GENDER

The regression analysis of the longitudinal data indicates that gender has no significant effect on the changes in attitude to science on transfer, thus supporting the suggestion of Power (1981). Girls are significantly less positive than are boys about science both before transfer and after transfer. Using only cross-sectional analysis it seemed possible that girls might be less affected by the transfer than boys, but when the year six data is taken into consideration (via regression analysis) this does not appear to be the case. There are no significant differences between boys and girls in the extent of their change in attitude on transfer. So, in general, secondary schools, in their induction process, do not appear to have any effect on the gender differences in science, which are already believed to exist. Therefore, it could be argued that secondary science departments are not taking into account the less favourable attitudes of girls; otherwise, the transfer process might lead to some reduction in the differences in girls and boys attitudes. On the other hand, the move to secondary school does not seem to have *increased* the differences either. So it could equally be argued that the changes in school structure and teacher approach has had neither positive nor negative effects on girls' attitudes.

However, change in enjoyment of school, which is linked with changes in attitudes to science, is also related to gender; girls' enjoyment of school is likely to decline more than that of boys (Table 7-12), and changes in attitudes to science appear to be linked with gender via enjoyment of school. Separate analyses of the data for boys' and girls' enjoyment of science (Tables 7-5 and 7-6) suggest that different aspects of the changes on transfer may affect them. Boys' change in enjoyment of science is related to the academic success of the school and, in particular schools, the use of more collaborative work than at primary school is linked with positive change in enjoyment of science for boys. However, for girls neither of these appears as a significant factor, but the use of the CASE scheme seems to have a negative effect on their enjoyment of science. Perhaps, as Stark (1999) suggested, boys have more positive attitudes to group work than girls, and girls' attitudes are less affected by changes in this aspect of science teaching. Similarly, it has been suggested that girls have less positive attitudes to CASE than boys (Whitelegg, 1996), so boys may be less affected by this change than girls.

When data from *individual* schools are analysed separately, it would appear that particular school structures and backgrounds, or their respective teaching approaches do make a difference (see Appendix 7). But it might be unwise to rely on such simplistic inter-school comparisons, since the numbers of pupils per school involved in the survey, and the socio-economic environments of the schools differed widely. However, the regression analyses also reveal the importance of differential effects in school structural and background factors, and also in teaching approaches. Gender differences appear to be implicated by each of these variables suggesting that changes in attitude to science at transfer are linked, although indirectly, with gender.

7.2.2 Liaison strategies

Liaison strategies appear to be important; the use of transfer information is a significant variable in the regression analyses with 'enjoyment of science' (Table 7-3, p.413) and 'difficulty of science' sub-scales (Table 7-9, p.414) as dependent variables. The length of the induction programme also appears as a significant variable in the regression analysis with enjoyment of school as dependent variable (Table 7-12, p.414). Finally the availability within a school of timetabled time for liaison is a significant variable in attitudes to the use of computers in science (Table 7-13, p.434).

In schools where transfer information obtained from primary schools is regarded as useful by heads of science, enjoyment of science increases and difficulty of science decreases on transfer (Figures 7-10 & 7-11).

Figure 7-10: The relationship between changes in enjoyment of science and the school's view of the value of transfer information

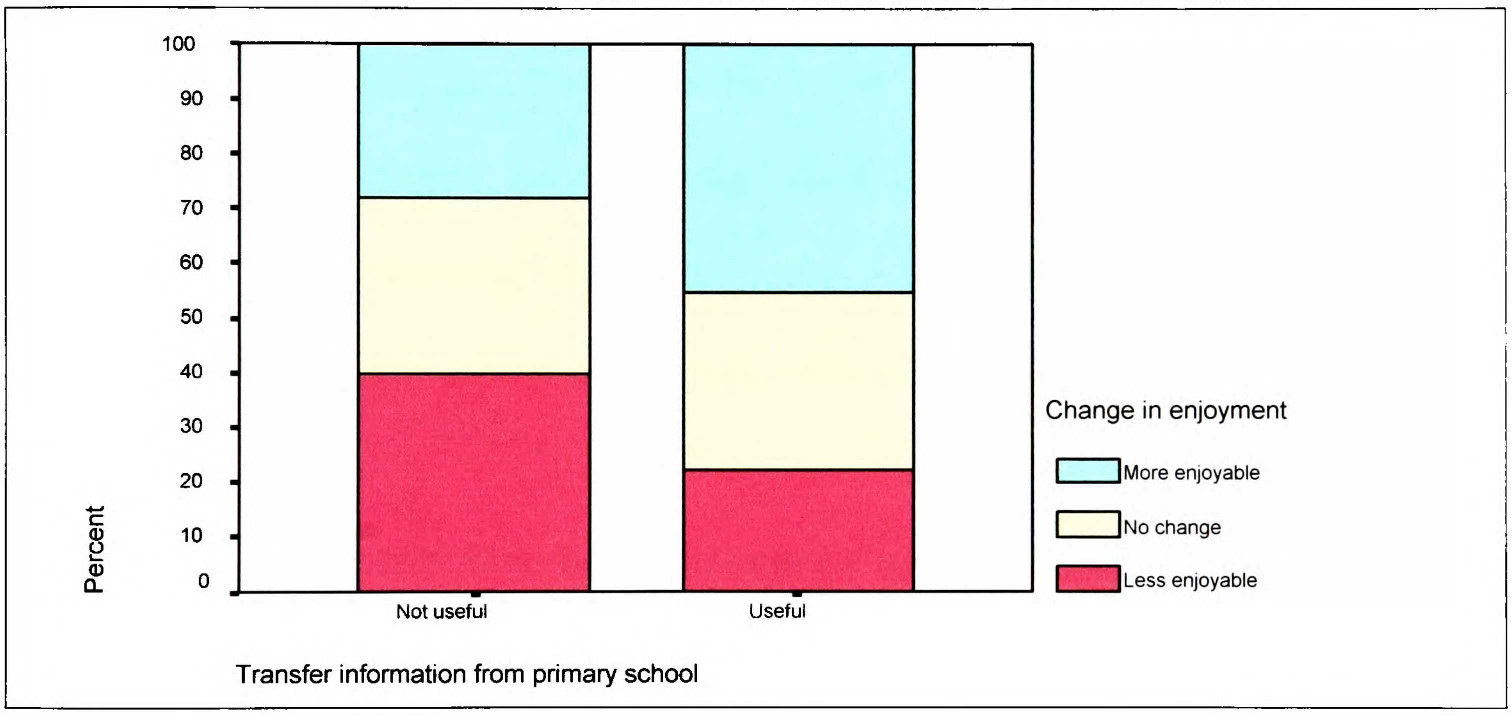
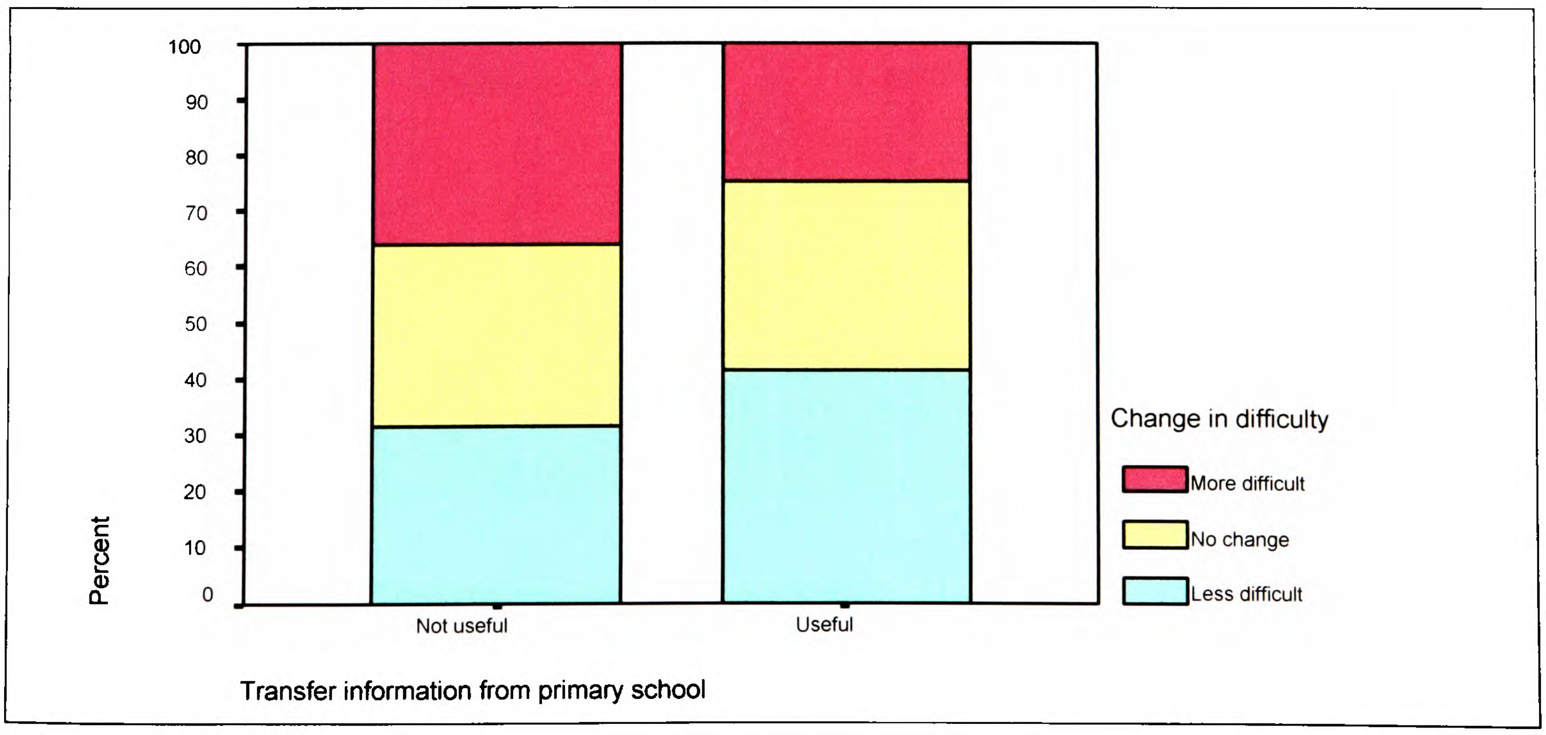


Figure 7-11: The relationship between change in difficulty of science and the school's view of the value of transfer information



Although the focus here was on two particular strategies rather than on the full range of liaison strategies, these results indicate that children enjoy science more and find it less difficult if there is good transfer of information, as advised by SCAA (1996). Furthermore, if poor transfer of information hinders curricular progression, as indicated by Schagen and Kerr (1997), then perhaps the present results reflect that children enjoy science more and find it less difficult when there is good curricular progression.

The length of the induction period seems to be important, the longer the period of induction the more negative the change in attitude is likely to be. Figure 7-12 shows this relationship for all schools. However, since only one school did not have any induction period, only one used three half-days and only one used four days the graph is somewhat distorted. Figure 7-13 shows the same relationship, but only for the larger number of schools using induction periods of a half-day, or one or two full days.

Figure 7-12: The relationship between change in enjoyment of science and length of induction period

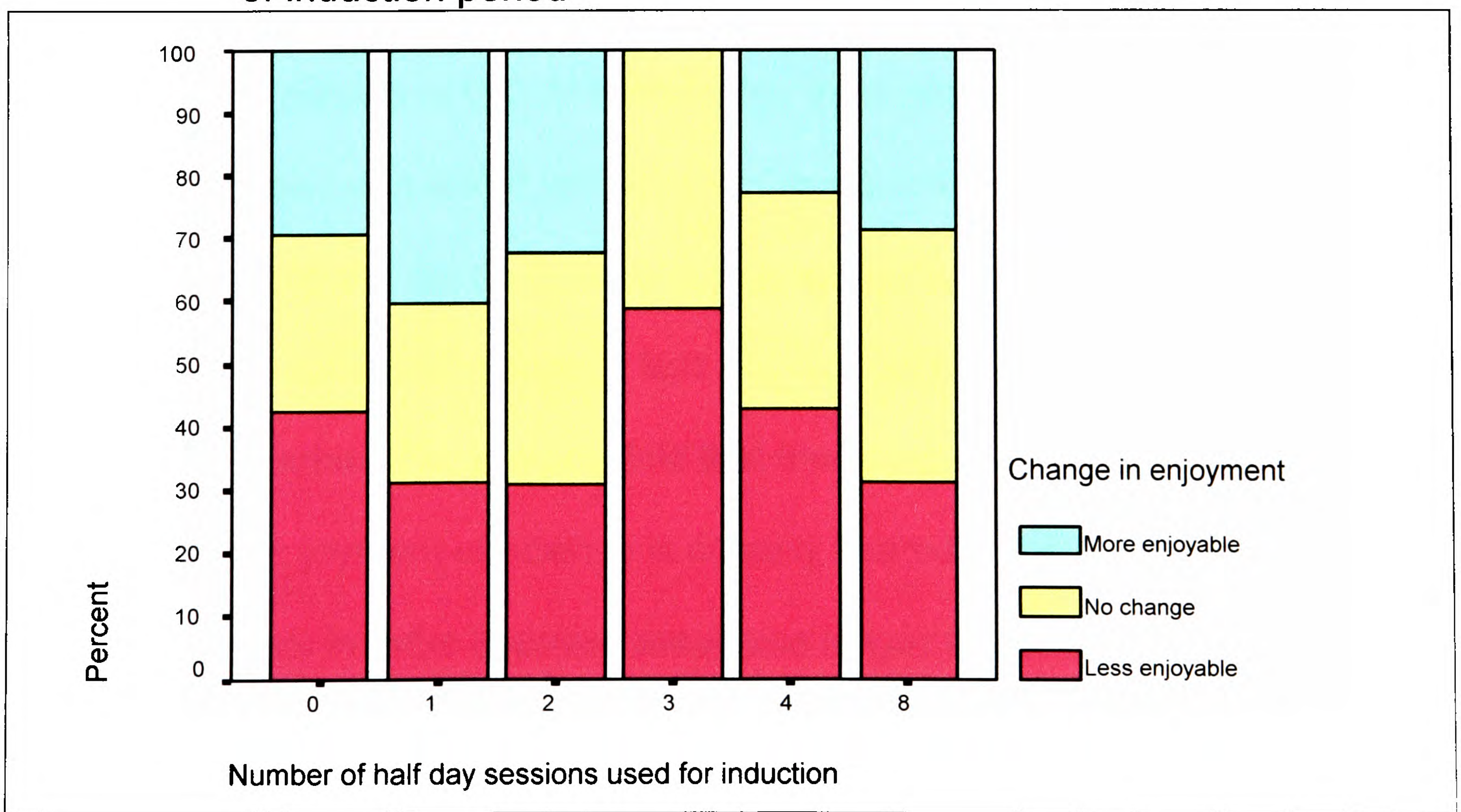
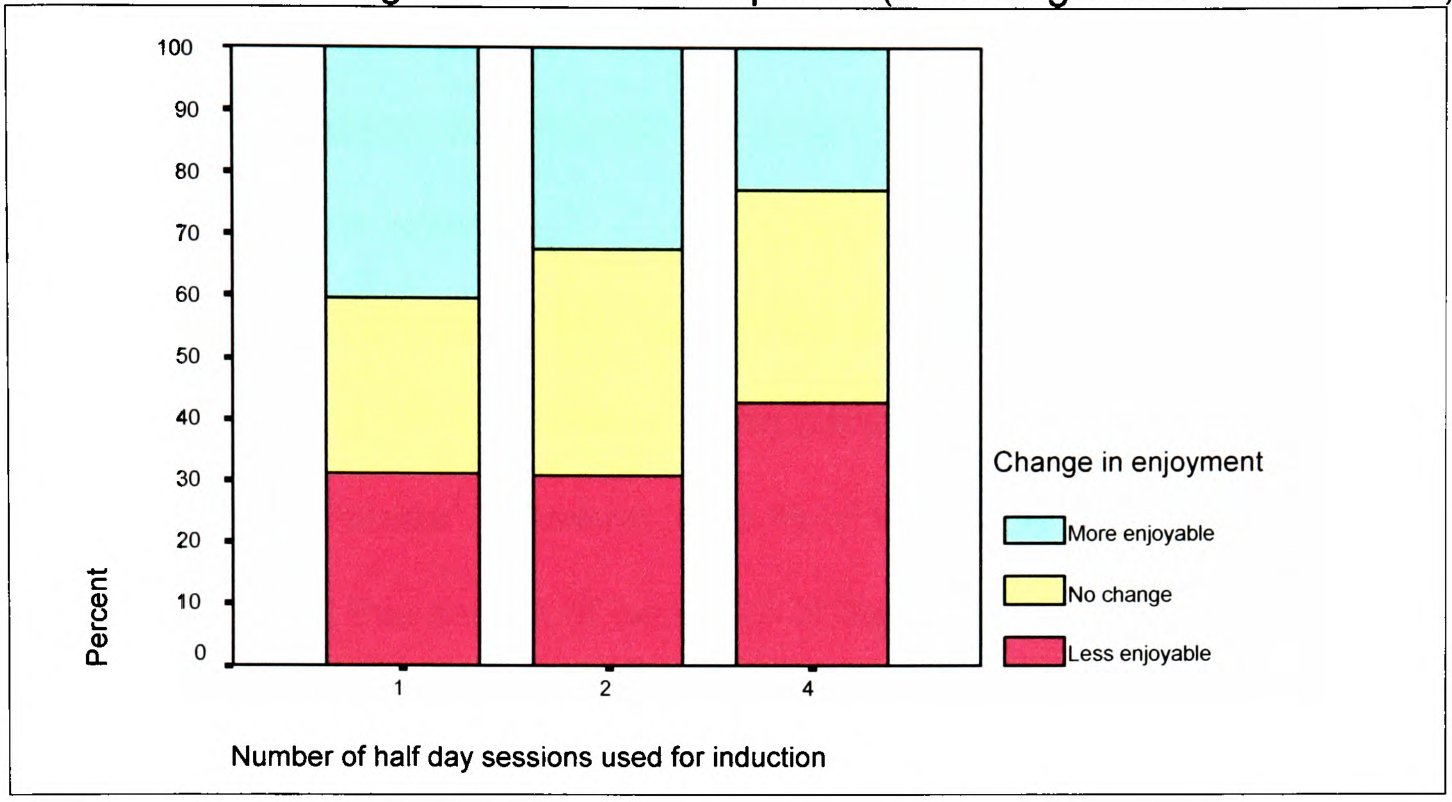


Figure 7-13: The relationship between change in enjoyment of science and the length of the induction period (excluding anomalous schools)



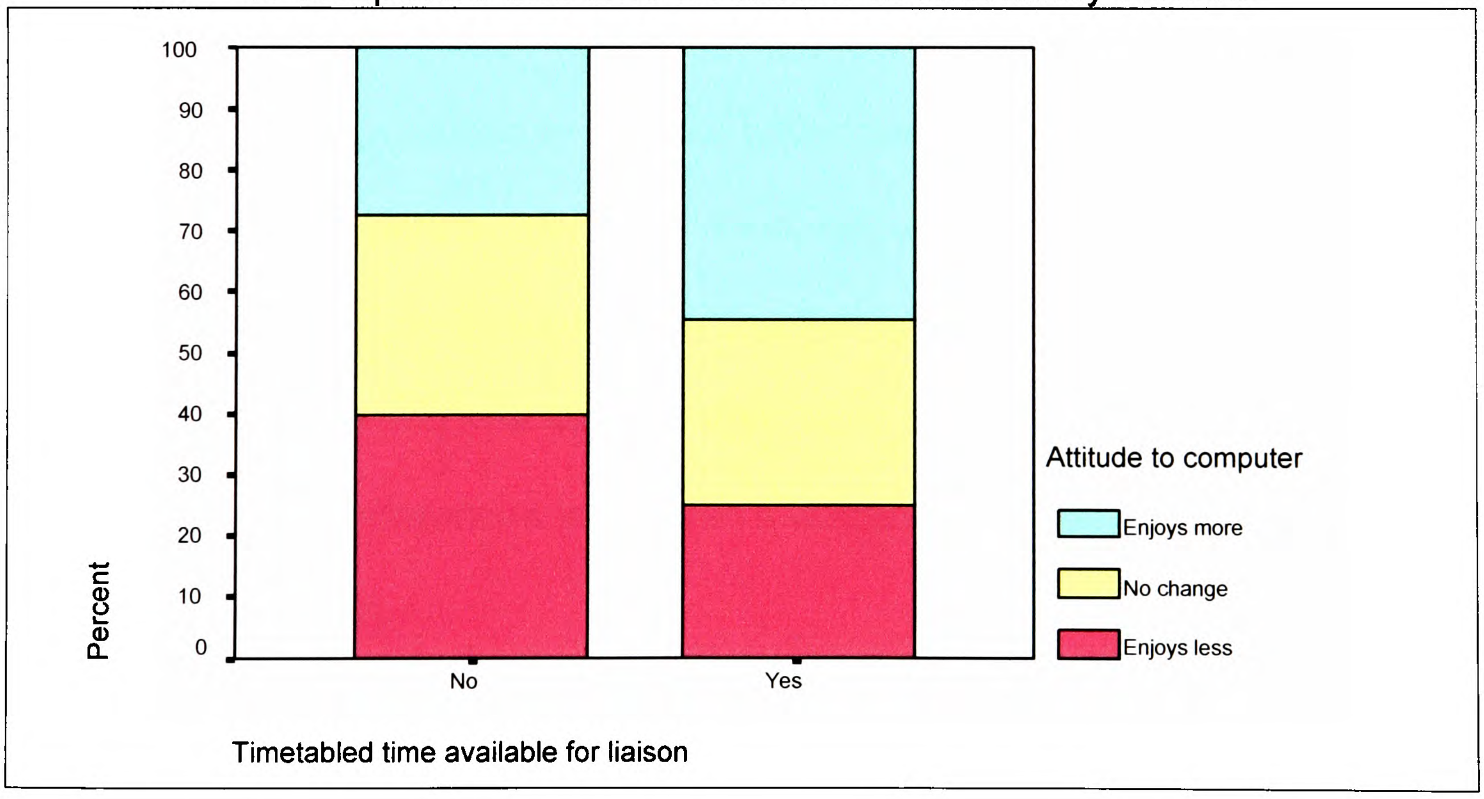
It seems possible, looking at Figure 7-12, that children having no induction or a very long induction period are likely to become less positive about science (and school). However, looking at Figure 7-13, which includes a wider range of schools in each category, a two day induction period might be too long: children in this category were more likely to become less positive.

In Chapter 4 (page 237) it was observed that schools with lower proportions of examination passes at GCSE used longer induction periods, and examination success has also been linked with levels of socio-economic deprivation. The present study and the literature have indicated that such indicators are also associated with attitudes to school; less positive attitudes being associated with more deprived areas. So, it is possible that the apparent link between length of induction and enjoyment of science is actually related to the level of deprivation in the area: schools in more deprived areas use longer induction periods but also have an intake of children with less positive attitudes to school.

Finally, changes in attitudes to the use of computers appear to be significantly related to the availability within a school of timetabled time for liaison. In schools where time is available the children are likely to have more positive attitudes to the use of computers in science.

It may be that schools with sufficient funds to make such timetable time available for liaison are also able to make computers more widely available to individual subject areas[1]. However, only 14 of the 34 secondary schools gave information about this aspect of liaison (5 of these made time-tabled time available for liaison), and furthermore a large number of children did not respond to the attitudes to computers in science sub-scale (Appendix 4). So, although this finding appears to be important, it must be treated with some caution.

Figure 7-14: The relationship between change in attitude to the use of computers and time for liaison at secondary school.



On the whole the evidence concerning the use of transfer strategies indicates that they may have important effects on children's attitudes to science on transfer.

[1] It was noted in Chapter 4 that attitudes to the use of computers may well depend on the frequency of use, and that frequency of use was extremely low in the majority of the secondary schools surveyed.

However, as described in Chapter 4 (page 229), it seems likely that relevant transfer information was not getting through to many of the science departments in the survey. Twenty-three of the Heads of science in the survey schools (69.7%) said that the transfer information was either not available or not useful. This problem may lead to a decline in children's positive attitudes towards science.

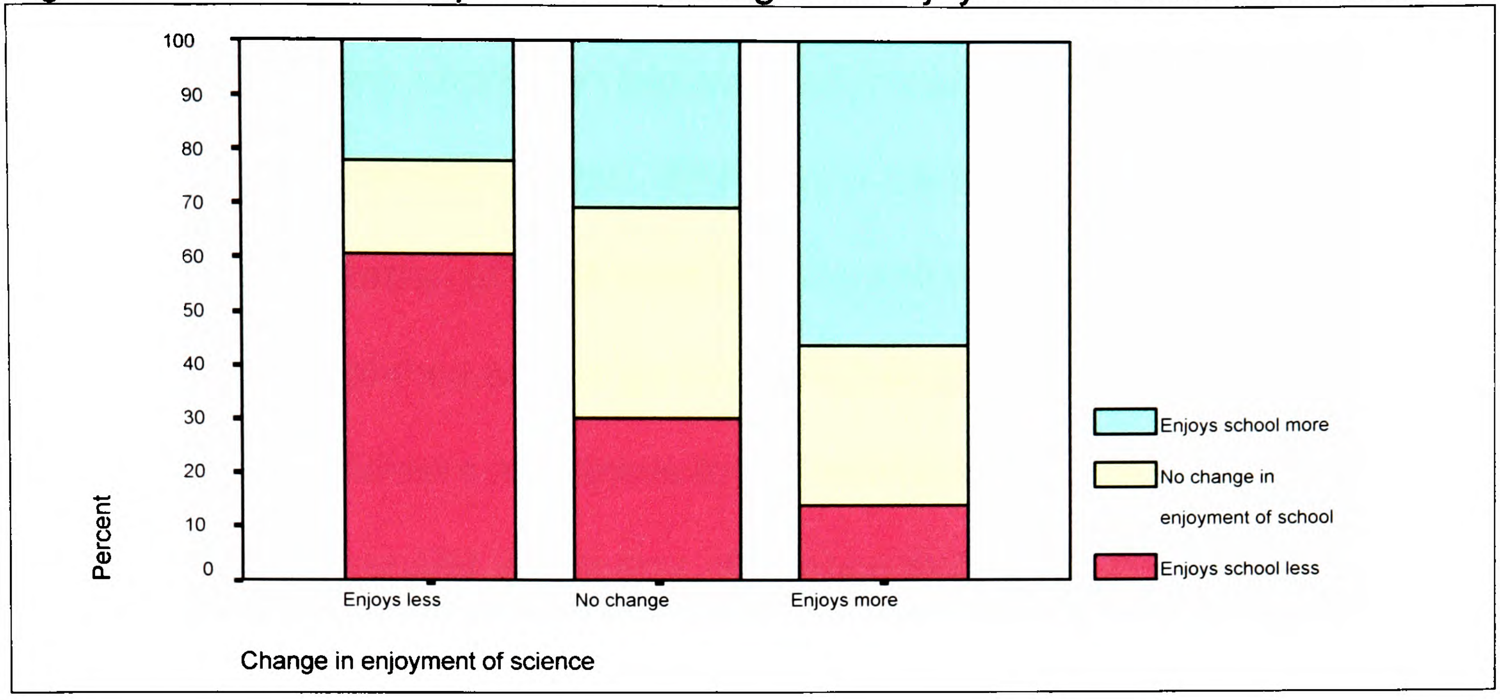
7.2.3 Socio-economic variables

This longitudinal analysis indicates that individual structural differences between schools (such as size of school) are less important than the socio-economic factors, represented by the proportion of GCSE examination passes and percentage of free school meals for each school (Tables 7-4, 7-6, & 7-10, pages 404-405). Using the cross-sectional data, it was suggested in Chapter 5 that social deprivation might affect children's attitudes to science, and the longitudinal analysis supports this suggestion.

Changes in attitudes to science have been linked with socio-economic indicators in three ways by this study. First, through the very strong association with changes in attitude to school; second through the regression analysis, where attitudes to science and free school meals were seen to be significantly related; and third through differences in children's written responses, according to social group (in Chapter 6).

To take the first of these, children's changes in attitudes to science are most closely linked with their changes in enjoyment of school; in every regression analysis (Tables 7-3 to 7-11) the change in enjoyment of school was the factor explaining the greatest amount of variance. This relationship is shown in Figure 7-15, below.

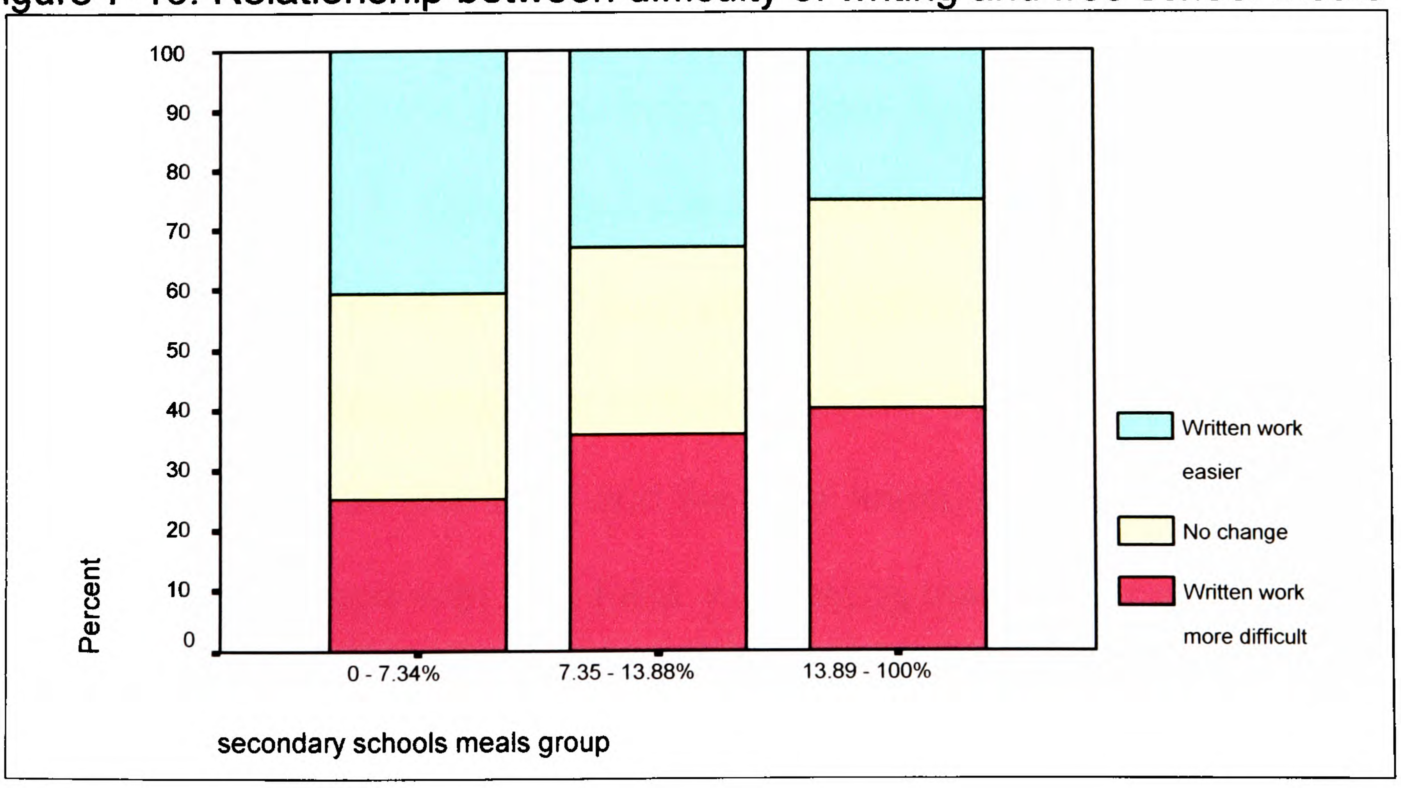
Figure 7-15: Relationship between changes in enjoyment of school and science



Attitude to school has previously been linked with social class (e.g. Barker-Lunn, 1971; Sammons & Mortimore, 1990) in Chapter 2 (page 71); therefore, it could be argued that since social class and attitude to school are linked, then social class and *attitudes to science* are likely to be linked.

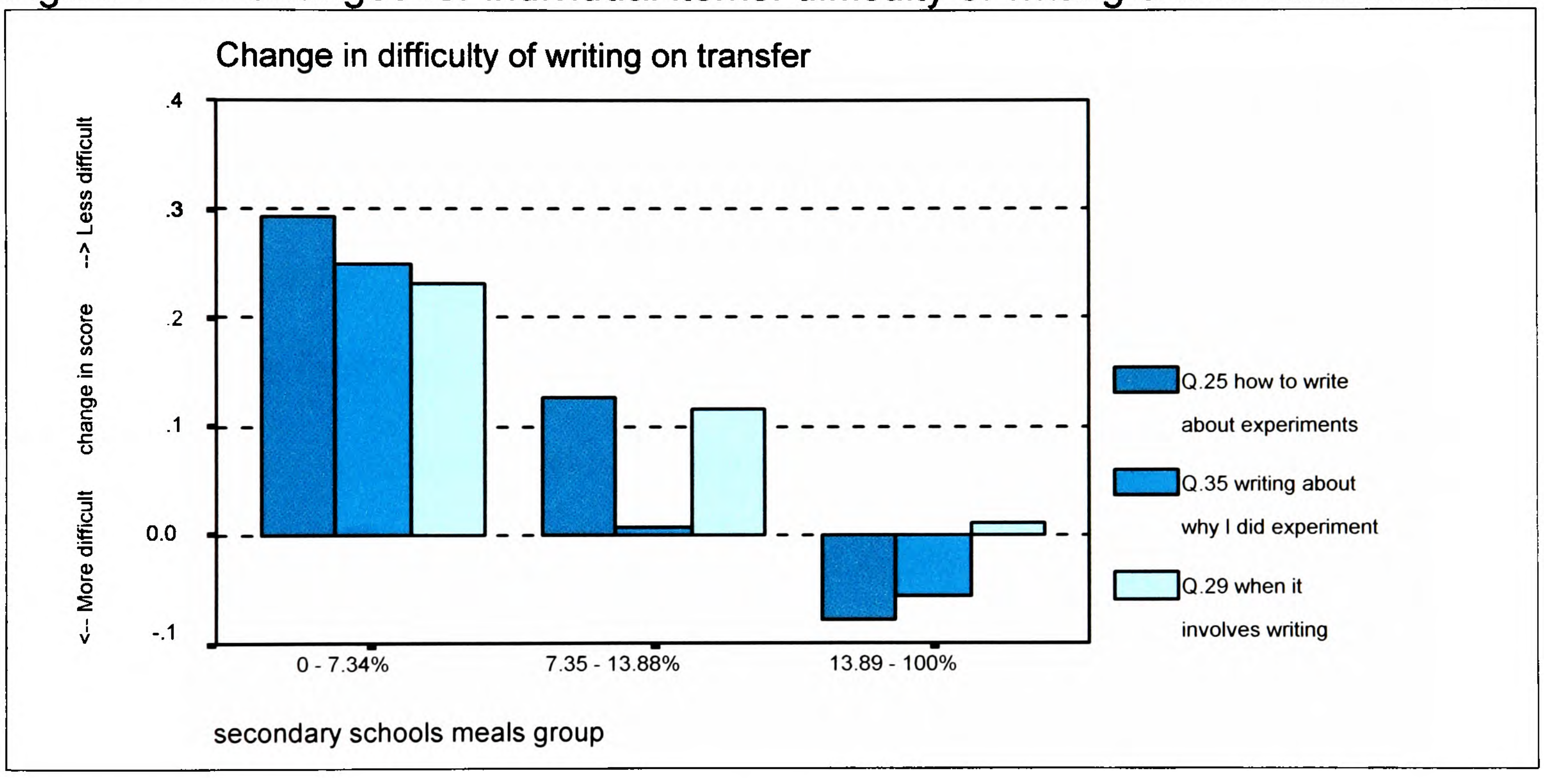
The second indicator of this relationship between attitudes to science and social class is that the level of free school meals taken by the school is significantly related to the difficulty of science written work (Table 7-6 & Figure 7-16).

Figure 7-16: Relationship between difficulty of writing and free school meals



In Chapter 4 (page 203) it was suggested that writing was not seen as a particular problem, but that the *understanding* required in order to do the writing was a more important issue for some children. As Figure 7-16 shows children from schools with a higher proportion of FSM were likely to find writing more difficult after transfer (in terms of their scores on the writing factor as a whole). However, the changes in the children's responses to the individual items in this factor (Figure 7-17) show that on transfer all aspects of science writing appear to become easier for children in schools with low FSM.

Figure 7-17: Changes for individual items: difficulty of writing & free school meals



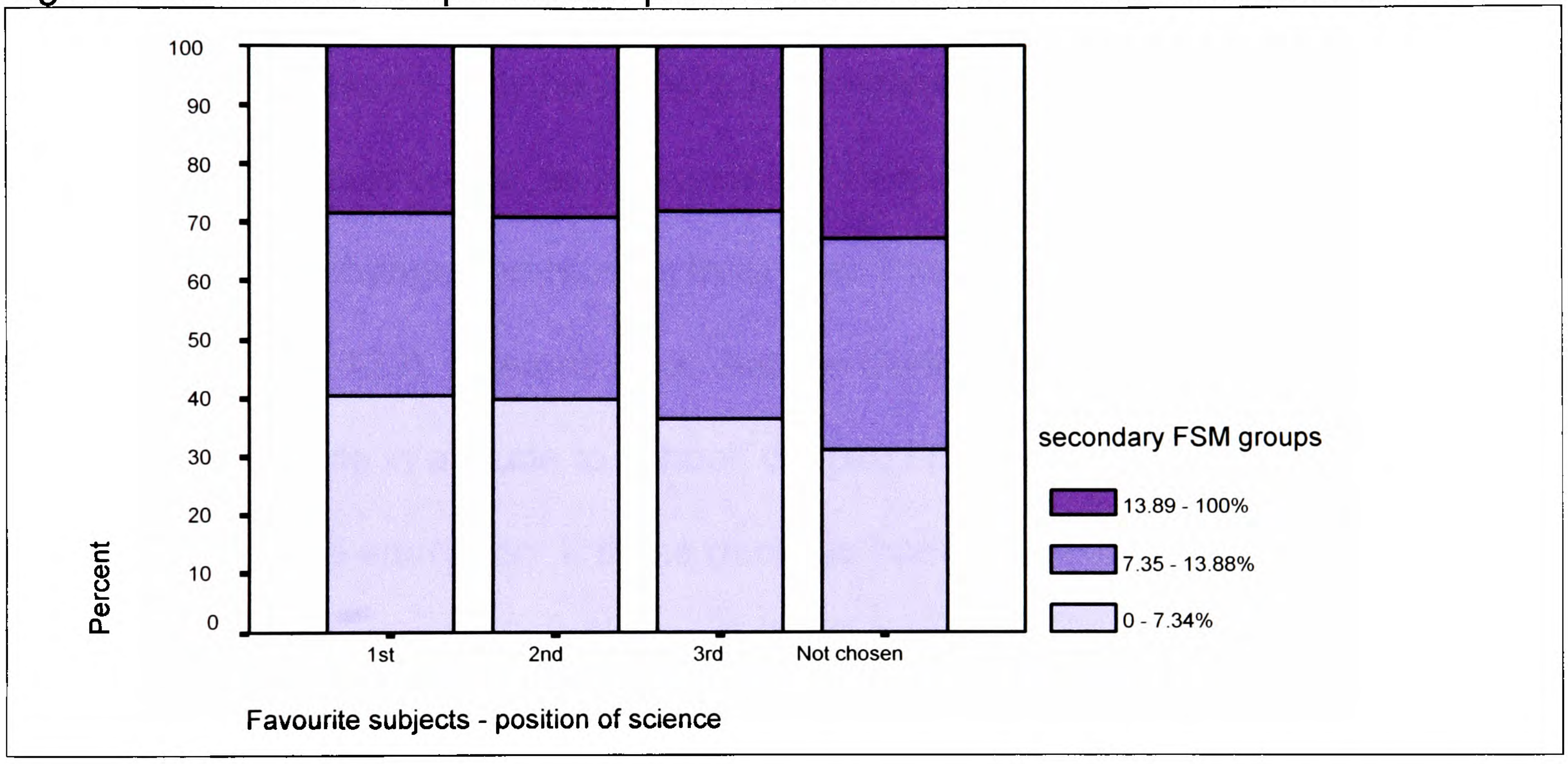
In addition, although the general trend indicates that writing may become more difficult for children in higher FSM schools, responses to item 29, 'science is difficult when it involves writing' suggest that writing in science becomes easier on transfer to secondary school for children from all FSM groups. However, it is clear that items 25 and 35 (the 'how' and the 'why' items) become more difficult for children from schools with high FSM, suggesting that there may be a decline in the understanding of science for the group of children in schools in more deprived areas.

Social class is recognised as one of the most important and persistent influences on *achievement* in school subjects, including science (Demack, Drew & Grimsley, 1998; McNiece & Joliffe, 1998; Kutnick, 1999). However, as discussed in Chapter 2, research into the relationship between *attitudes* to science and social class has been limited. It has been suggested that attitudes to *mathematics* have more to do with class and society than with ability (Brown & Riddell, 1992; Fennema, 1996), but a similar relationship for science and social class has not been evidenced. However, a number of studies have indicated that there is a significant correlation between achievement in science and attitude to science. Therefore, it could be argued that since social class and achievement in science are linked, then social class and *attitudes* to science are also likely to be linked.

In Chapter 2, the literature concerning subject choices and subject preferences as indicators of attitudes was reviewed. Such research may offer an insight into the relationship between social class and attitudes to science, since such choices and preferences were often set in the context of social groupings. Before 1986 many studies examined attitude to science via students' subject choice at age 14, but since that time science has been a compulsory subject in the 5-16 curriculum. Accordingly, most research of this nature since 1986 has involved asking students about their preferred subjects rather than looking at the subjects that they choose to study. Subject preferences and subject choices are likely to be linked, since reasons for choosing particular subjects are related to enjoyment, career aspirations and perceived ability (Wikeley & Stables, 1999).

However, as discussed in Chapter 2, the use of subject preferences as a measure of attitudes is seen as rather a blunt instrument, and, for that reason, was not the preferred research instrument in the current study. Nevertheless, some subject preference information was gathered, as a reliability check, and appreciable differences were found in the subject *preference* of different social groups. Science was the more preferred subject for children from schools with a low proportion of FSM, and the least preferred for children from high FSM schools at secondary (Figure 7-18). The differences were significant at secondary school ($p<.002$, chi squared test), but there was no significant difference at primary school.

Figure 7-18: Relationship between preference for science and free school meals



However, caution must be exercised when looking at research linking *subject choices* with social class. Set or stream generally restricts subject choices (Abraham, 1995), and where streaming or setting is used, there is a high correlation between low social class and low set or stream (Abraham, 1995; Boaler, 1997). Thus, children from different social groups are making subject choices in different circumstances. Nevertheless, some recent research suggests that there may be a significant relationship between subject preferences and social class (Croxford 1997 and 2000; Tinklin et al, 2000).

The effects of subject status, and stereotyping, by parents and by society, are also involved in any decisions about subject choices. Science is regarded as a high status subject (Maden, 1995) and children from more affluent backgrounds tend not to opt for lower status, non-academic subjects (Abrahams, 1995; Croxford, 1997 and 2000). Thus, subject choice and preference are likely to be related to social background, and the reason for the greater decline in enjoyment on transfer for children from lower social groups may be due to their different expectations of secondary school (Nisbet & Entwistle, 1969). The status and stereotyping associated with science may be working against the expectations of children from more deprived backgrounds, as suggested in Chapter 5.

When the changes on moving from year 7 to year 8 are included, (see Figure 7.24, page 429), it seems clear that the decline in attitude to science parallels the decline in attitude to school, despite improvements in attitude to other aspects of science education. If these declines had matched only on transfer, it would have been possible to argue that the decline in attitude to science was due to the general change of school environment on transfer. However, the trend continues through year 8 as well, thus it seems likely that the decline in enjoyment of science is related more to general changes in attitude to school. It has been suggested (page 330) that attitudes to school may be closely linked to social and cultural variables and there is some support for this view (Barker Lunn,1971; Sammons and Mortimore,1990).

The qualitative evidence in Chapter 6 also suggests that children from schools with a higher proportion of FSM may be less positive about science; attitudes to school declined most among children from areas with indicators of high social deprivation, and least for children from more affluent areas.

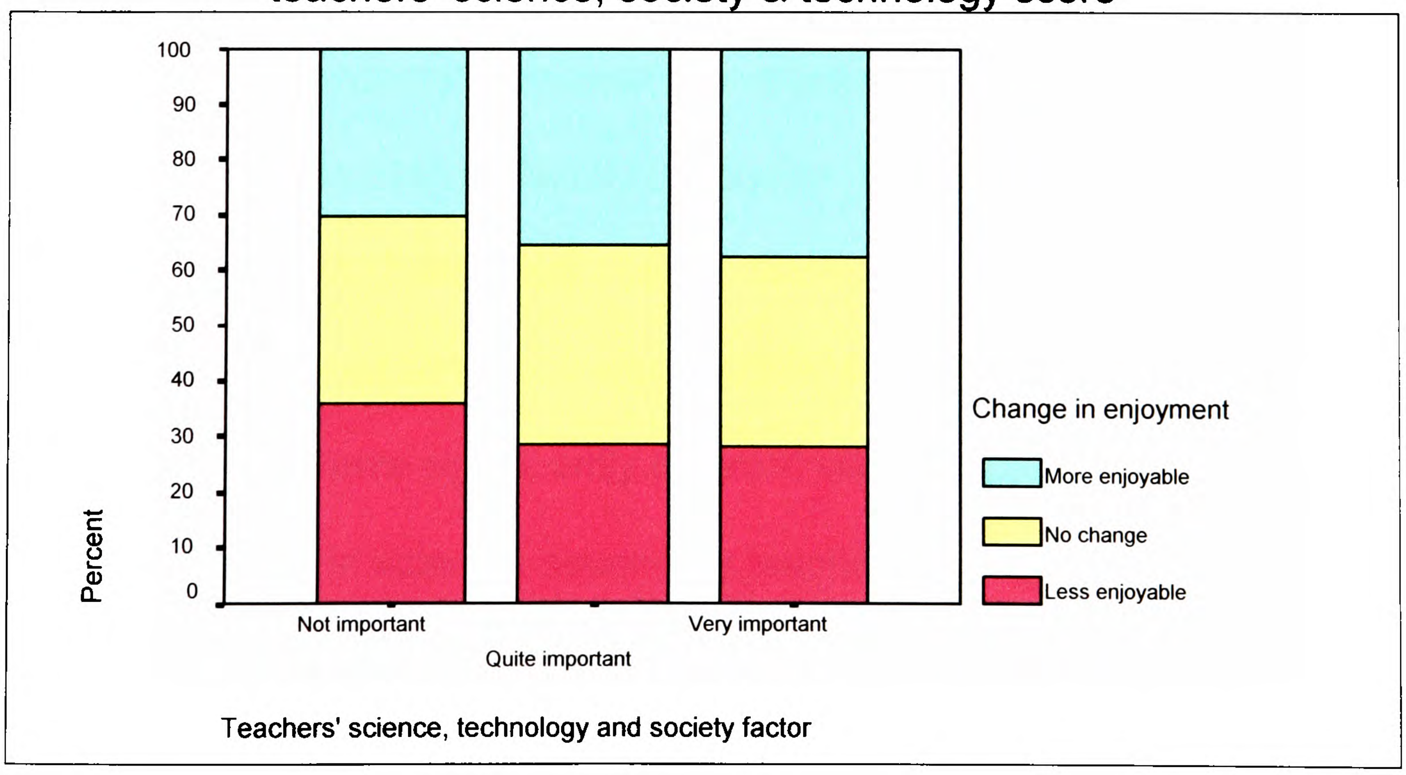
So the declining attitude to science with age would appear to be rooted to some extent in social and cultural stereotypes rather than the more common explanations such as 'the difficulty of science', and 'the abstract nature of science'.

7.2.4 THE TEACHERS' VIEWS.

Analysis of the available data in this study indicates that teachers' own views may have some effect on children's attitudes, although the amount of the variation explained is small. Nevertheless, these results are important because they show that the personal views of teachers seem to affect the changes in pupil attitude on transfer.

The secondary teachers' science, society and technology factor[1] (f2) score is related to children's change in enjoyment of science, and as Figure 7-19, below, shows, the analysis suggests that children are likely to enjoy science more if teachers regard the items making up this factor as important.

Figure 7-19: The relationship between change in enjoyment of science and teachers' science, society & technology score



[1] This factor is made up of three items: 'Making the connections between science, technology and society', 'Showing that science knowledge is tentative and changing', and 'Using time to study applications of scientific concepts'.

Since there was no significant difference in scores on this factor for primary and secondary teachers (page 247), it is difficult to understand why this should be influential on children's changing enjoyment of science lessons. It is possible that secondary teachers who feel that this aspect of science teaching is important (and gaining high scores on this factor) might use distinctive types of classroom activity. Non-parametric Kruskall-Wallis tests were used to compare the frequencies of classroom activities (indicated by the children's questionnaire) for each of three groups of secondary teacher: those who thought f2 important, quite important, or not important. The tests indicated that secondary teachers who felt that f2 was important used significantly more student directed and significantly less teacher directed classroom activities (Appendix 8). So, it is possible that teachers' feelings about the emphasis they place on different aspects of science teaching have an affect on children's attitude to science and that this might come about via the particular classroom activities used. This must remain a tentative suggestion since the statistical tests used did not control for the effects of other variables.

The secondary teachers' process-content factor score[1] is related to children's change in perceptions of the difficulty of science, and as Figure 7-20 shows, this analysis suggests that children are likely to find science less difficult if teachers take a more content-based view. It was established in Chapter 4 that primary and secondary teachers have significantly different views about the importance of process and content in science: secondary teachers seem to regard a process approach as less important than do primary teachers.

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[1] The process-content factor comprised three items: ' Science education should be more about the learning of scientific processes than the learning of scientific facts', 'The most valuable part of a scientific education is what remains after the facts have been forgotten', and 'Scientific method' is transferable from one scientific investigation to another'

Figure 7-20: The relationship between change in difficulty of science and teachers' process-content score

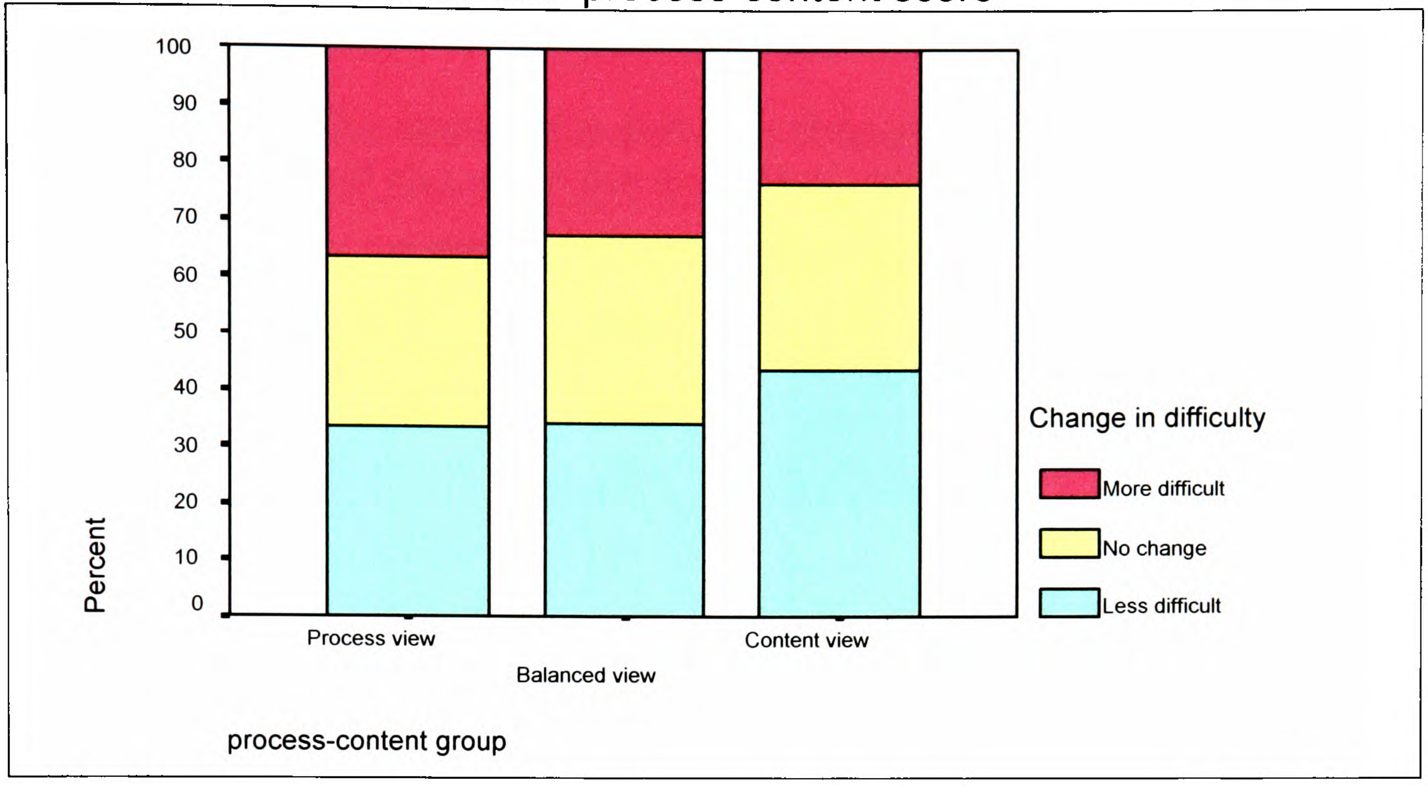
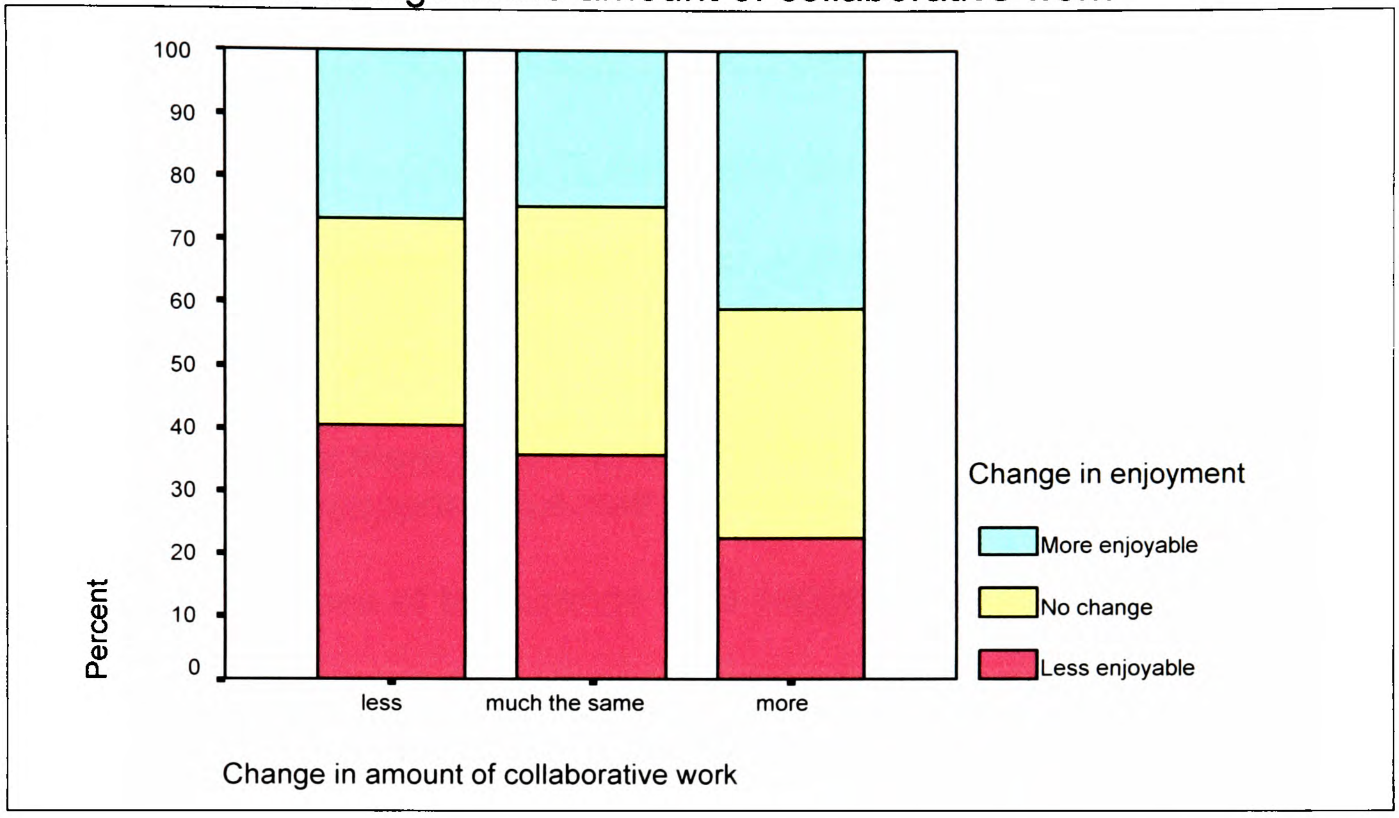


Figure 7-20 shows that children taught by a secondary teacher with a content view are likely to find science less difficult after transfer, and children taught by a teacher with a process view are likely to find it more difficult. This might be related to the apparent mismatch between children's and teachers' perceptions of the aims of process-based work described by Watson et al (2000): although teachers had chosen to undertake investigative work in order to develop certain skills and processes the children thought that the investigation was being used to teach specific content. Such a misunderstanding may explain the differences observed in Figure 7-20.

7.2.5 Pedagogy

The learning activities used in the science class appear to be significantly linked with changes in attitude towards science on transfer, in particular the use of collaborative learning and teacher directed learning approaches. Children who experienced more collaborative working on transfer were likely to enjoy science more at secondary school. This relationship, suggested by correlation coefficients and supported by regression analysis, is shown in Figure 7-21.

Figure 7-21: The relationship between change in enjoyment of science and change in the amount of collaborative work



The change in the amount of collaborative work on transfer is significantly linked with changes in enjoyment of science whereas the amount of collaborative work at primary school alone is not. Thus, even where secondary schools place considerable emphasis on collaborative work, pupils may still *perceive* a reduction if their primary school had frequently adopted this teaching style. This is an important point and highlights the necessity for close links between primary and secondary schools. The need to keep up a dialogue to assist curriculum progression has frequently been stressed (for example, School Curriculum and Assessment Authority, 1996) but the changes in pedagogic approaches are less often considered (Galton, 1999).

The frequency of small-group practical work generally increases on transfer and its positive effect on attitudes to science can be seen as support for the view that use of practical work and working in small groups may improve attitudes to science. But unless there is an *increase* in the amount of active learning on transfer it is unlikely to be an effective motivator, as is suggested by this typical comment, from a pupil whose attitude to science declined on transfer:

> *3112 *My old school had better experiments than here! And we have the same things here but here is more difficult. (Boy)*

However, as discussed in Chapter 6, there was generally an increase in practical laboratory work and this had a positive effect, increasing pupil autonomy in science lessons, for example:

> *2579 *Science is more intresting as in primary school are Teachers told us what happened but now we find out for ourselves. (Boy)*

The regression analyses of the change data suggest that it may be this *difference* between activities at primary school and at secondary school that is important. If the secondary school uses collaborative work less than the primary school or increases the amount of teacher directed learning then it is likely that the pupils will view science less favourably after transfer. However, it also follows that where the pupils in primary schools do little collaborative work, or the science teaching is too controlled, then the secondary schools are likely to enjoy at least an initial period in which the pupils make positive comparisons and have more favourable attitudes to science. Science has been credited with offering greater variety of teaching styles than other academic subjects and pupils may base their opinion of secondary science on how much variation in style of teaching and activities is perceived, in comparison with primary school science (Cullingford, 1991; Kinder, Wakefield and Wilkin, 1996). At transfer, secondary science has a huge advantage over primary science; it offers a completely new environment and frequent opportunities for practical work. This advantage accounts for much of the positive comment made about secondary science, for example:

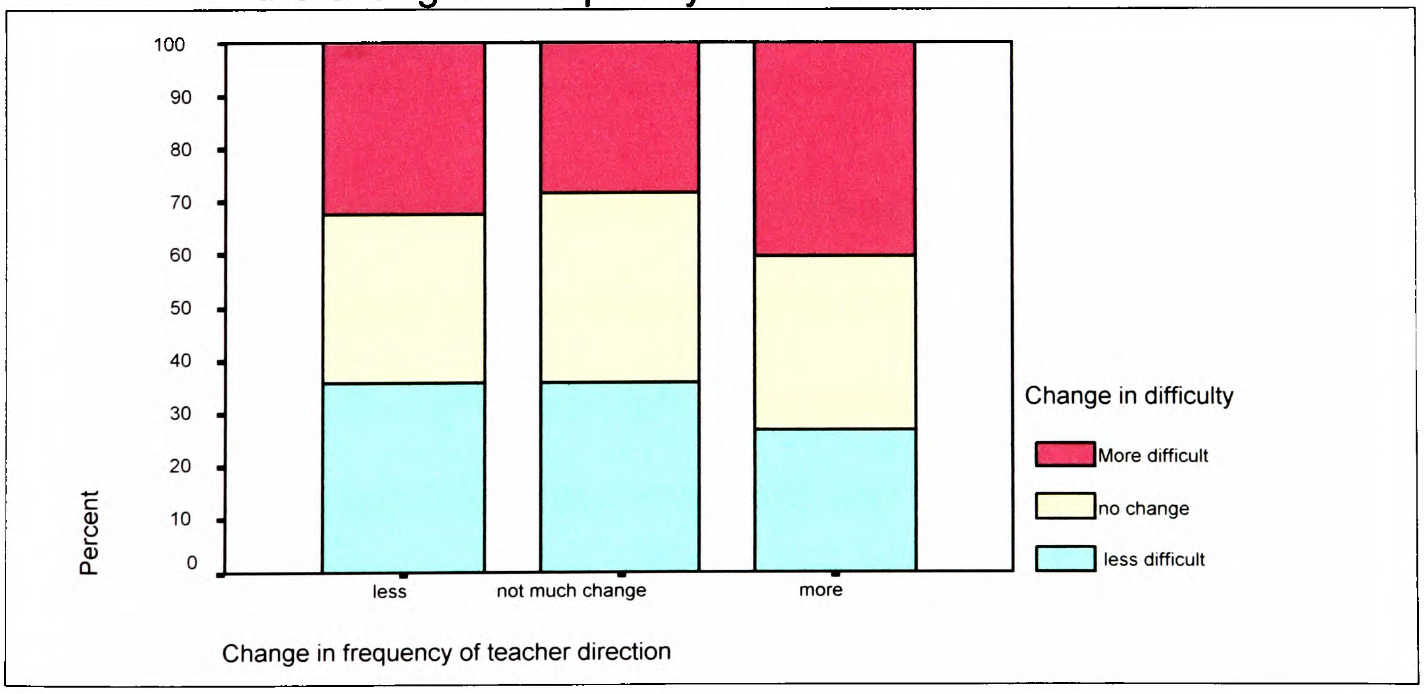
* *3251 I think Science is much better at [Secondary school] because we have Labs and do more experiments. I used to dread Science but now I enjoy it. I never used to be able to write up experiments but not it is easy (my teacher may say different but I think I'm good at writing up experiments!) at [primary school] we never used to use Bunsens or anything like that Secondry Science is much better than boring Primary Science. (Boy)*

But the amount of variation is also an important factor as shown in this comment:

**905 Science at secondry school is better than science at primary school. Because at secondry school we do things like acids, the body etc, wereas at the Junior we did experiments like grip on shoes. In other words science at secondry school varyes but at Junior school it was the same thing every time. (Boy)*

Children who experience more teacher-directed activity on transfer are also likely to find science more difficult, as shown in Figure 7-22. On the other hand, if children have moved from a primary school where the science teaching was very controlled then they may feel that secondary science is less difficult.

Figure 7-22: The relationship between the change in difficulty of science and the change in frequency of teacher direction

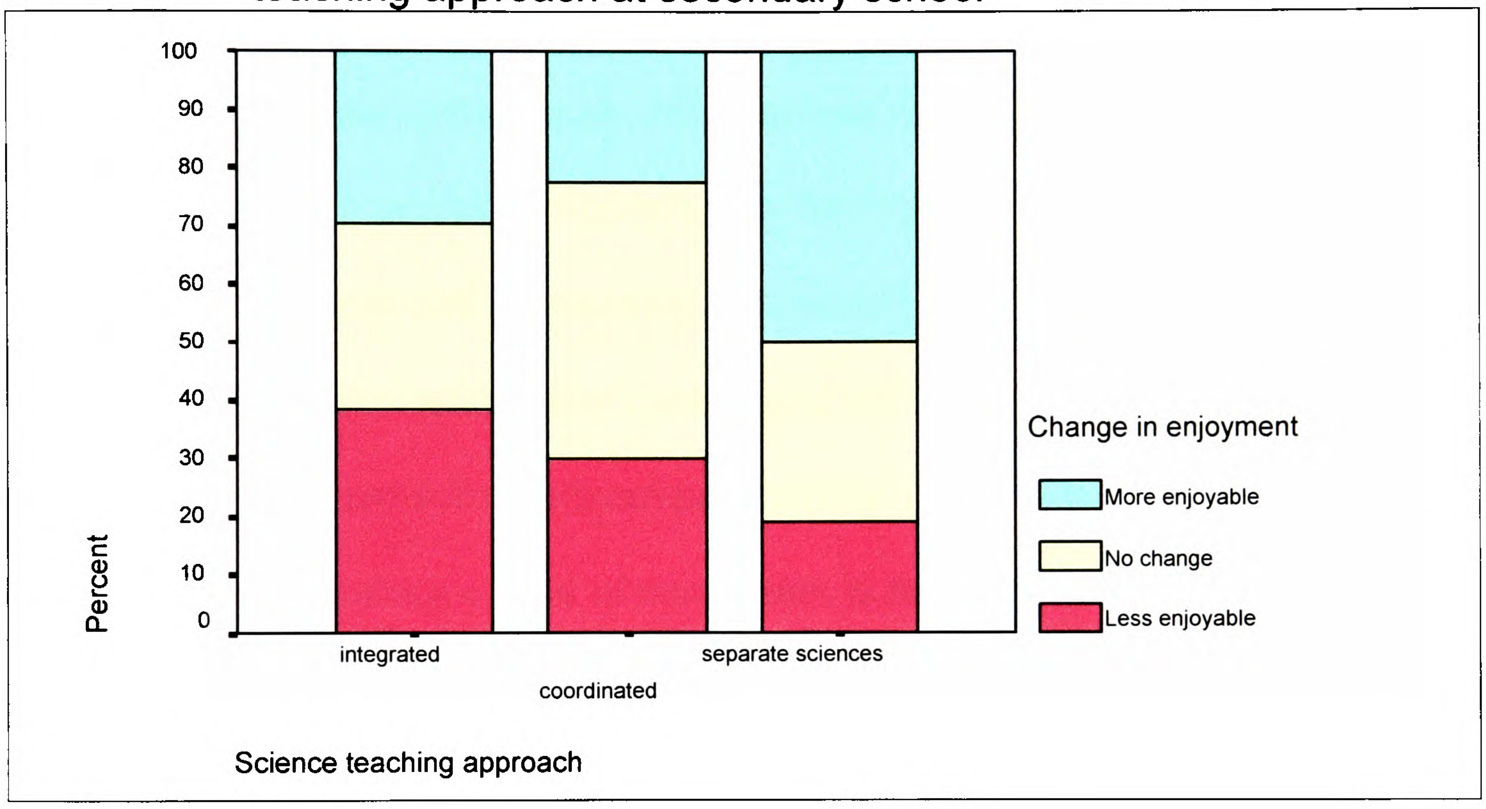


The links between attitudes to science and teacher-directed and collaborative activities indicate that changes in classroom activities on transfer might be particularly important.

7.2.6 TYPES OF TEACHING APPROACH

The various teaching approaches used at primary and secondary schools were included in the regression analyses, but only one approach appeared to be influential; where science was taught as three separate sciences children were likely to become more positive about science on transfer (Figure 7-23).

Figure 7-23: The relationship between change in enjoyment of science and teaching approach at secondary school



Schools teaching separate sciences might be selective or in more affluent areas, but the earlier analysis of school variables in Chapter 4 has not shown any such links. So it seems that children might enjoy science more when they are taught the three sciences separately. This finding may well be related to the children's written comments in Chapter 6, about chemistry in particular. Many children looked forward to 'chemistry lessons' but only children in schools using 'separate science' would be in a position to recognise easily that they were doing 'chemistry'. This finding is supported by some recent research (Reiss, 2000), where it was observed that in their first year of secondary science chemistry topics were mentioned particularly often by children.

7.2.7 Use of computers

Table 7-13: Significant variables for the change in attitude to using computers in science

Regression block	Predictor variable	R Square	R Square Change	Unstandardized Coefficient B Constant = -0.76
Secondary school	Timetabled time available for liaison	0.017	0.017	0.42
	CASE	0.029	0.012	0.34
Change in attitude to school	Change in attitude to schoolwork	0.040	0.011	0.22
	Change in enjoyment of school	0.050	0.010	-0.13

Attitudes to the use of computers are significantly linked with the difficulty of science and science written work, although not with enjoyment. It is inferred from this finding that the use of computers may have particular value in making science easier to understand and the reading and writing more accessible. But, since ease of understanding and written work are linked with enjoyment of science the use of computers may have some indirect part to play in changing attitudes. Still, the change in the frequency of use of computers is not linked to changes in enjoyment of science, and so it seems unlikely that increased use of computers alone would bring about positive changes in attitude to science.

7.2.8 Perceptions of continuity and progression

The lack of a relationship between children's perception of continuity and the other science attitude sub-scales (Table 7-2, page 403) suggests that changes in enjoyment and in the perceived difficulty of science may be unaffected by perceptions of continuity and progression. This is an important issue because breaks in continuity have been cited as an explanation of more negative attitudes to science at secondary school (Chapter 1). However, the data analysis from the present study does not support that view, and the evidence from the qualitative written comments in this study support the quantitative finding; most children do not regard such repetition as the issue (page 374). It will be recalled that, when talking about similarities and differences between primary and secondary science, about 30% of children made comments about *similarities*. Some of these children suggested that similarities or repetition could be helpful, making secondary science easier to understand, and others found science 'boring' because of the similarities, and were clearly very disappointed not to see a change in style and content of their science lessons.

However, few children expressed either of these two views, and there was a far greater emphasis on the enjoyment resulting from the *differences* in both style and content. As was observed in Chapter 6, when in their last year at primary school, most of these children were looking forward to change rather than continuity. The transfer from primary to secondary school has been identified as a major '*rite de passage*' (Measor & Woods, 1984; Inkson, 1988), and as such it *should* involve changes. Progression has been defined (Chapter 1) as curricular progression, and continuity as continuance of the style of delivery. For these children there was a change in teaching style, a discontinuity, and a far greater proportion of comments were concerned with differences in teaching style (over 60%) than with similarities (less than 10%). However, since curriculum similarities were mentioned by 15% of children but curriculum differences were mentioned by less than 8% it seems likely that curricular continuity was more usual than discontinuity. Comments made in the children's writing expressed these similarities and differences quite clearly: the 'topics' were 'the same' but the work was 'harder' or 'different'. Here are three typical examples:

**1547 The topics are the same, but we have more experiments and it's harder. (Girl)*

**703 We roughly do the same things but in a different way. We did electricity in our old school, but the experiment was different to the experiments we are doing now. (Girl)*

**1493 Learning about The 5 senses, the water cycle, sound and light are the same. But in secondary school you do experiments with cemicals .... in Junior school you don't....you have to write up experments in secondary school but you have to copy or use dicktation in junior school. (Girl)*

These findings are supported by a recent longitudinal study in which children found many teacher and teaching differences but many curriculum similarities on transfer (Hawkey & Clay,1999).

Thus, it seems that a balance may have been achieved between a *rite de passage* and continuity; children encounter similar subject matter, but at the same time they meet a change in teaching style and learning experiences. For a minority, there may be too much or too little repetition, but the majority of children seem to recognise that the similarities are limited and that the 'same topic' is more challenging. To return to the original observation concerning correlation coefficients, the lack of correlation between perceptions of continuity and enjoyment might be seen as a reflection of this balance. If the majority of children accept that there is some value in both change *and* repetition then *continuity* is unlikely to be related to their overall attitude to science.

7.3 Changes on transfer compared with year 7 to year 8

The changes in attitude on transfer, although statistically significant, are quite small, and it has been suggested that the transfer from year 6 in primary school to year 7 in secondary school may not cause as great a change in attitude as the transfer from year 7 to 8 at secondary school (Doddington, Flutter, & Rudduck, 1999). It has also been suggested that any transfer is likely to cause changes in attitude and dips in progress (King Rice, 1997). Furthermore, since there is evidence to suggest that attitudes to science (and school) both decline with age, the changes observed on transfer may be ones that continue throughout each successive year. Therefore to demonstrate that the changes on transfer are crucial ones it is necessary to compare these changes with those on transfer between years at secondary school. In order to do this the same questionnaire was administered to the same cohort of students a year later when they were in year 8 of secondary school. Since these data do not form part of the original study their analysis is in its early stages; details may be found in Appendix 10.

Attrition reduced the sample size to 1320, as shown in Table 7-14.

Table 7-14: Size of the longitudinal cohort in years 6, 7 and 8

	Year 6	Year 7	Year 8
Number of children in longitudinal group	3370	2258	1320

Only 23 of the original secondary schools were involved in this phase of the research, neither of the grammar schools took part, but in this year, as in years 6 and 7, all children present at the participating schools at the time of the survey completed a questionnaire. The data for year 8 is compared with that for the same children, and the same schools, in years 6 and 7, and the mean standard scores on the sub-scales are shown in Table 7-15, below.

Table 7-15: Mean standard sub-scale scores for year 8

	Year 6			Year 7			Year 8		
	n	Mean	Std Dev.	n	Mean	Std Dev.	n	Mean	Std Dev.
Enjoyment of science	1108	4.07	.74	1100	4.01	.76	1203	3.84	.74
Difficulty of written work in science	1133	3.04	.87	1093	2.93	.87	1200	3.18	.86
Difficulty of science	1081	3.03	.88	1056	3.02	.93	1187	3.03	.94
Enjoyment of school	1068	3.56	.79	1048	3.28	.81	1217	3.11	.82
Attitude to schoolwork	1016	3.89	.64	1014	4.02	.56	1185	3.91	.62

Table 7-15 shows that the enjoyment of science and of school continues to decline into year 8, as does the difficulty of written work, but the difficulty of science and attitude to schoolwork change little. Paired t-tests compare the changes from year 6 to year 7 with those from year 7 to year 8, and indicate significant differences only for enjoyment of school and difficulty of written work in science.

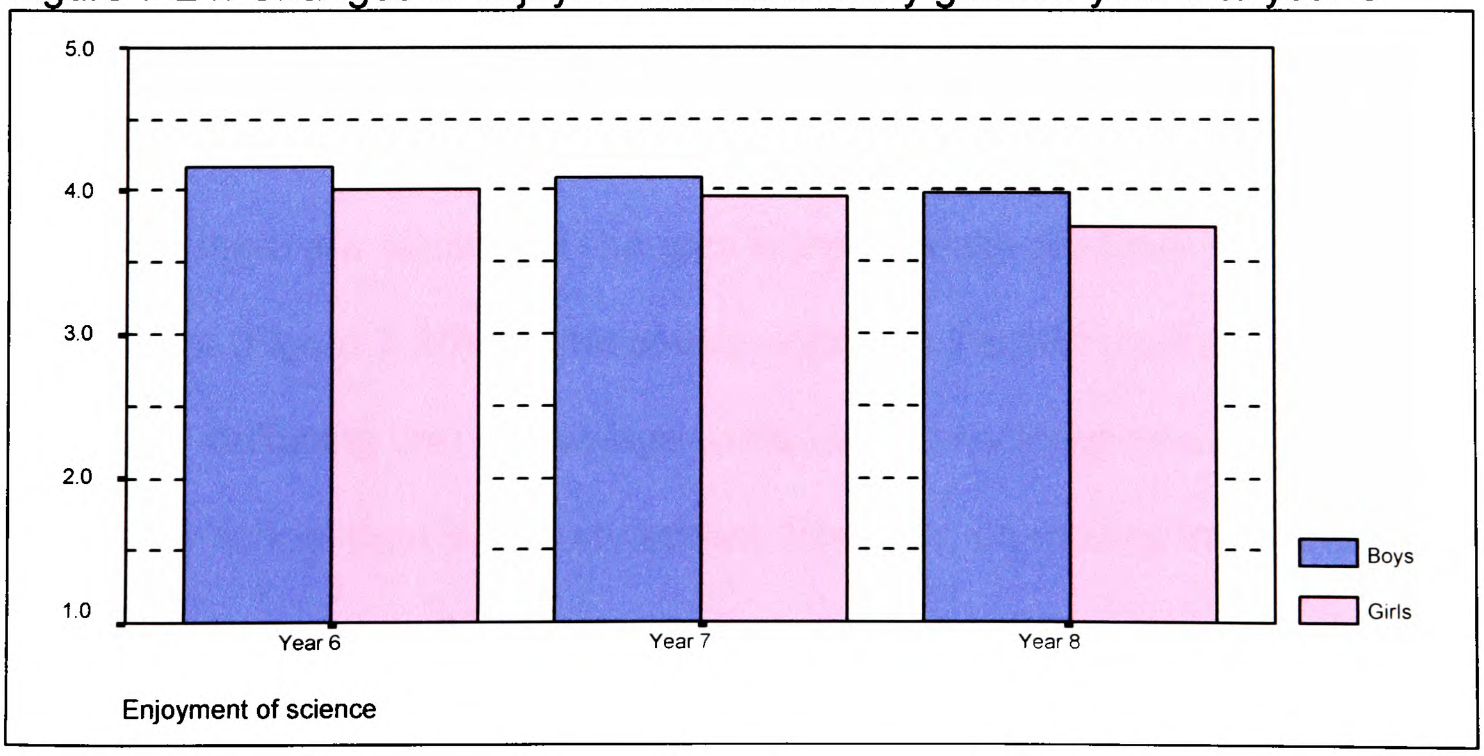
Table 7-16: Results of t-test comparing changes at transfer with changes on moving from years 7 to 8

	Paired samples used in t-test	Sig. (2-tailed)
Pair 1	Change in attitude to science lessons y6-y7 – Change in attitude to science lessons y7-y8	0.06
Pair 2	Change in perception of the difficulty of written work in science y6-y7 - Change in perception of the difficulty of written work in science y7-y8	0.00**
Pair 3	The change in the difficulty of science y6-y7 – The change in the difficulty of science y7-y8	0.40
Pair 4	Change in attitude to school y6-y7 – Change in attitude to school y7-y8	0.00**

**Test is significant at the 0.001 level.

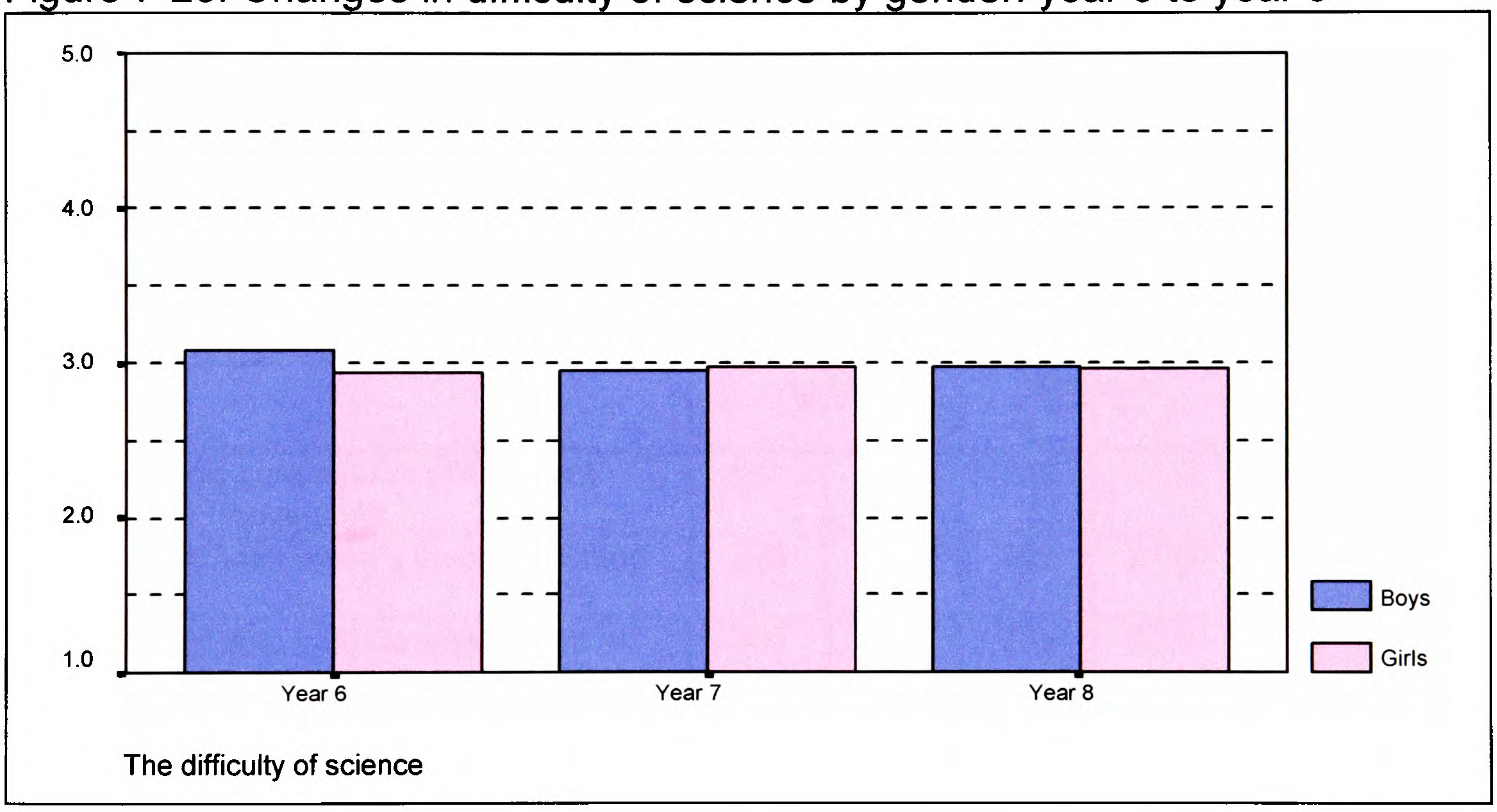
Thus, children's enjoyment of science continues to decline once at secondary school and there is no significant difference between the decline on transfer and the decline on moving to year 8. Furthermore, the decline is similar for girls and boys (see Figure 7-24, below).

Figure 7-24: Changes in enjoyment of science by gender: year 6 to year 8



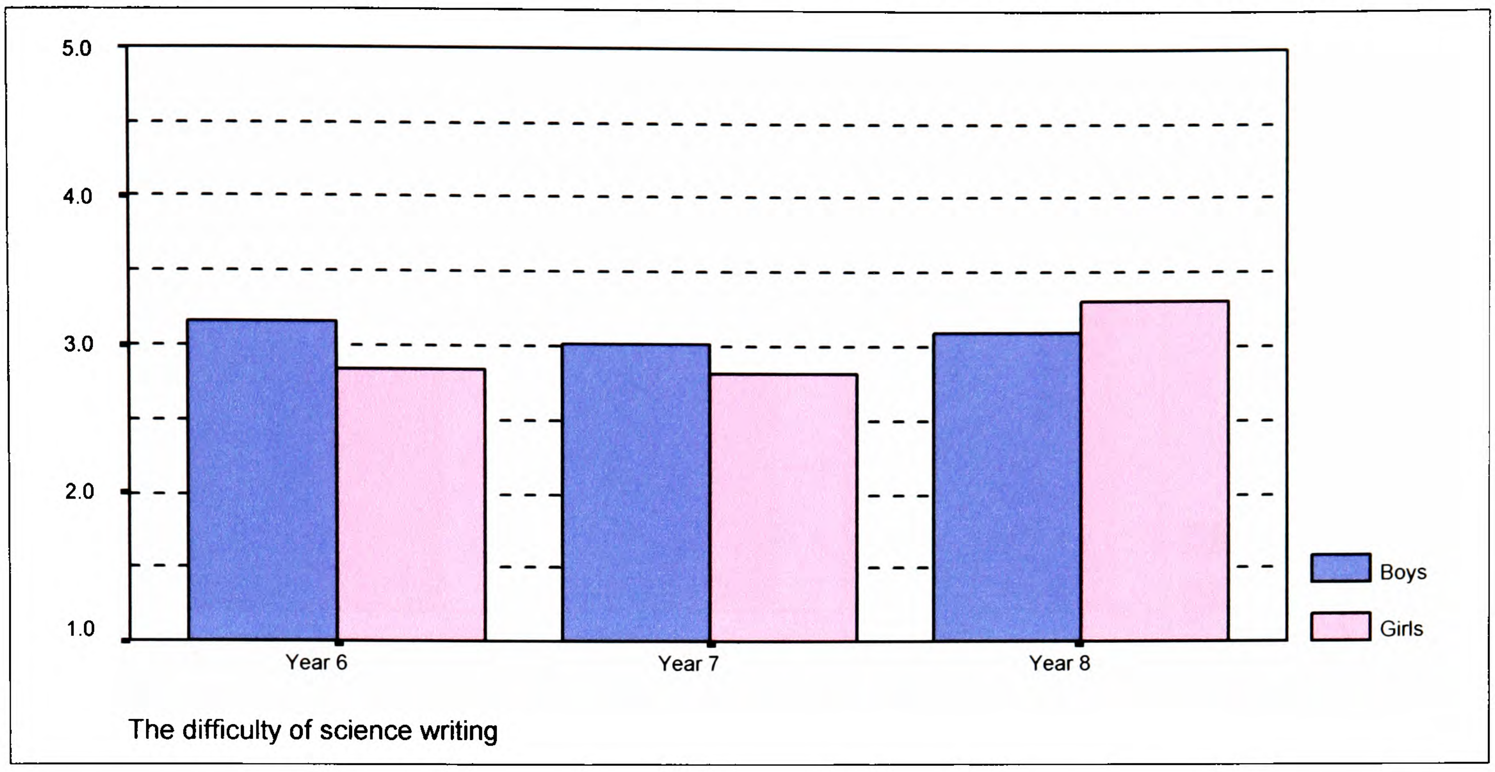
So, for this cohort, the decline in enjoyment of science at the time of transfer appears to be no different from the decline the following year, when these children did *not* transfer from primary to secondary school. The difficulty of science appears to change very little across the three years (Figure 7-25), and girls and boys have very similar scores on this scale, suggesting that difficulties of being presented with new vocabulary, increased factual information and new concepts are probably not important.

Figure 7-25: Changes in difficulty of science by gender: year 6 to year 8



However, there are significant changes in the difficulty of written work across the three years (Figure 7-26). As previously noted, on transfer the mean sub-scale score fell, indicating that on average written work in science was easier in secondary school than in primary school. However, on moving from years 7 to 8 there is a sharp rise in the mean sub-scale score, indicating that something about science written work (or understanding of science, as discussed on page 414) has become much more difficult.

Figure 7-26: Changes in difficulty of science writing by gender: year 6 to year 8



An inspection of the frequency of responses to the items making up this sub-scale clarifies this issue (Table 7-17).

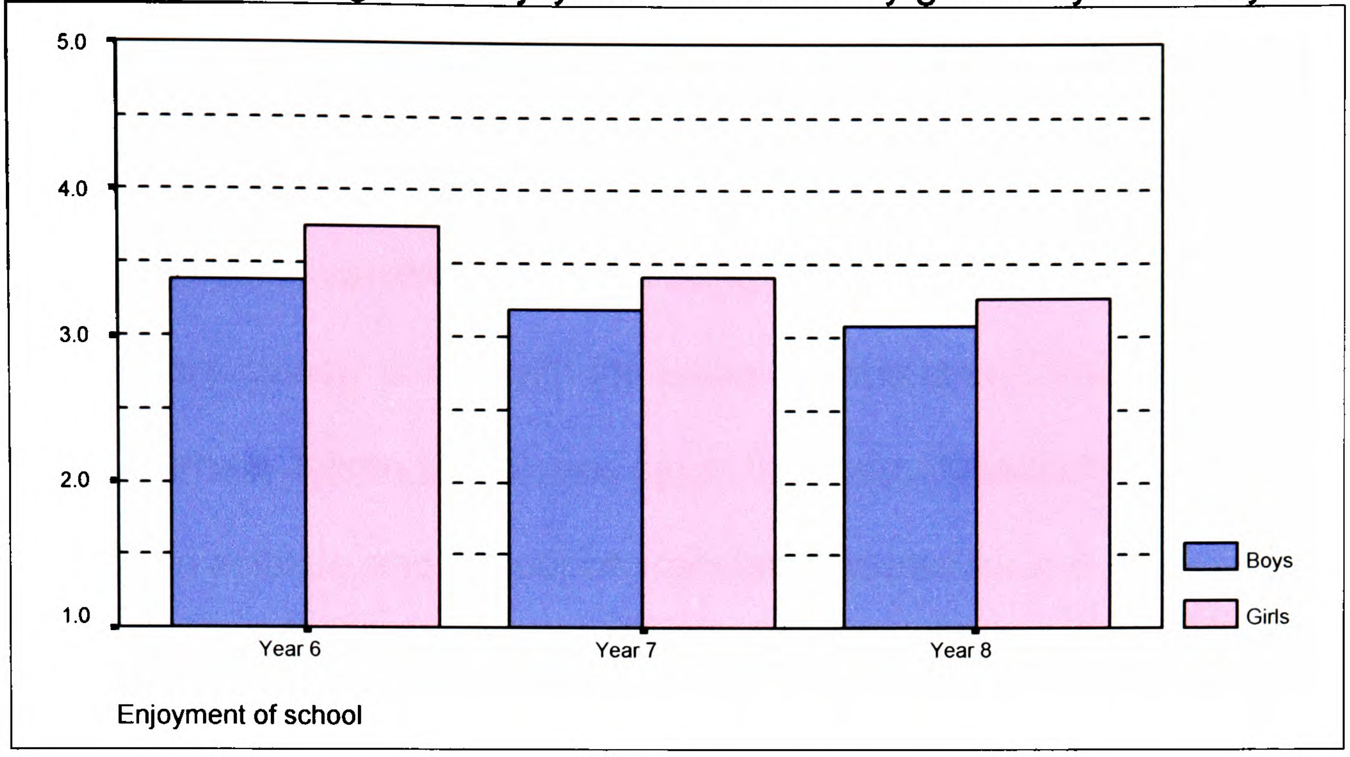
Table 7-17: Responses of year 8 children to the difficulty of written work in science items.

	Agree		Not sure		Disagree	
	n	%	n	%	n	%
I'm not always sure how to write about experiments I have done	631	48.7	200	15.5	463	35.8
Science is difficult when it involves writing	256	20.1	268	21.0	754	59.0
Writing about why I did an experiment is difficult	395	31.5	288	22.9	574	45.7

Most children are clear that it is not the writing itself, but the understanding required in order to write that is the problem. In particular, for almost half of these children (48.7%) knowing *how* to write about experiments was the difficulty. Thus, it appears that certain aspects of science get more difficult for these children on moving to year 8, rather than on transfer to secondary school.

Enjoyment of school declines significantly more on transfer than on moving from year 7 to 8 (Figure 7-27), and this pattern is found for both boys and girls. This finding does not support the research of Rudduck and others who have suggested that there may be a significant dip on moving to year 8.

Figure 7-27: Changes in enjoyment of school by gender: year 6 to year 8



Changes in enjoyment of science are positively related to changes in enjoyment of school, on transfer and on moving from year 7 to year 8, and yet enjoyment of school declines less on the move to year 8 but the enjoyment of science declines more. This suggests that any decline in the enjoyment of science in year 8 may occur because science becomes more difficult at this stage rather than because of a general decline in attitudes to school.

7.4 Summary

The factors associated with the individual children (gender and ethnicity) do not account directly for any significant variation in changes in attitude on transfer (in any of the regression analyses), indicating that the observed changes in attitude are more likely to relate to changes in external factors, such as socio-economic background, rather than to individual differences.

Only secondary teachers' view of science teaching and secondary school variables are significantly linked to changes in children's attitude to science, indicating the greater power of the secondary school environment to affect attitudes.

Most of the significant *school* variables are socio-economic rather than science specific variables, and it is suggested that attitudes to school and to science are closely linked with the socio-economic environment of the school.

Certain liaison techniques seem to be significantly related to changes in attitude to science and school on transfer: in particular the use of transfer information and induction days by the secondary schools. It seems that if secondary schools trust and use the transfer information provided by the primary schools then children's attitudes to science are likely to improve.

Changes in the type of teaching and learning activity (collaborative learning and teacher directed learning) seem to be particularly important. Where there is an increase in the amount of collaborative learning there is an increase in children's enjoyment of science and where there is an increase in teacher-directed activity children find science more difficult. Thus, a balance must be struck between these two approaches to ensure both enjoyment and understanding. With the exception of transfer strategies, the significant factors emerging from the change data were also significant for attitudes within each year. The main differences between the factors affecting each year and the factors affecting changes on transfer seem to be:

- Individual differences (gender and ethnicity) are important within a year group but do not influence overall changes directly.
- Transfer strategies have significant effects on changes in attitude on transfer but appear to have no influence on attitudes within a year group.

- Differences between primary and secondary teachers' views about science and science teaching and classroom activities may have important affect attitudes.
- Changes in attitudes to school have a major part to play in changing attitudes to science.

The similarity of the changes taking place on moving from year 7 to year 8 in secondary schools and the changes on moving from year 6, in primary school, to year 7, in secondary school, suggests that the transfer from primary to secondary school may be less influential on attitudes to science than has previously been thought.

CHAPTER 8. IMPLICATIONS AND CONCLUSIONS

8.1 Introduction

The context of the research was set out in Chapter 1, the research literature in this area was discussed in Chapter 2, and the methods and theoretical approaches used were presented in Chapter 3. The research findings were then described and discussed in Chapters 4 to 7. In this final Chapter, the main objectives of the thesis are re-examined in the light of the research findings.

First, the extent to which the main aims of the study have been met is described, in section 8.2, and the distinctive features emerging from the study are discussed in section 8.3. Possible further research arising from the present study is suggested in section 8.4, and finally, in section 8.5, recommendations for professional development are offered.

8.2 To what extent have the aims of this study been met?

The overall aim of this research was to investigate whether there were changes in pupils' attitudes to science as they moved from primary school to secondary school, and if so, to quantify those changes. The outcome reveals a mixed picture.

On examining individual changes it was clear that although some children's attitudes change on transfer, most do not; and of those that change some become much more positive about science while others become much more negative. The proportion of children whose attitudes decline significantly at this time is relatively small, and the overall changes in enjoyment of science occurring on transfer are not very different from those that occur on moving from year 7 to year 8.

The overall decline in children's attitudes is similar to those found by Hadden (1981) and Power (1981) who undertook similar, large-scale longitudinal studies in Scotland and Australia, respectively. At this superficial level, the findings suggest that the introduction of the National Curriculum in science may have had little effect on attitudes to science. In addition, the present study has also provided evidence that this change is similar to that on moving from year 7 to year 8 within the same school, which suggests that the time of transfer may not be as important as has been suggested by the literature; at least in terms of its effect on attitudes to science. On the other hand, it could mean that the introduction of the National Curriculum has reduced the discontinuity in science education, so that the time of transfer is now less critical than it has been in the past.

The second main aim of the study was to examine the extent to which teaching style changes on transition from primary to secondary school. Allusions to a difference in style between the teachers in the two sectors are common, but the research evidence in support of such suggestions is generally based on comparisons of studies made at different times, by different researchers using different instruments and samples. However, in this study, the use of the same questionnaire for both primary and secondary teachers has led to the identification of specific differences in outlook between the teachers in the two sectors. There appears to be quite a distinct difference between teachers' outlook and an abrupt change in the most frequently used classroom activities. Primary school teachers tend to have a skills-based, child-centred view of teaching and to use more collaborative, and less teacher-directed activities than the secondary school teachers. Secondary school teachers are more likely to adopt a subject-based view of teaching, and to use less collaborative and more teacher-directed classroom activities. These findings support the suggestions of such differences within the literature (for example, Lee, Harris & Dickson, 1995). Such evidence suggests that despite efforts to increase the subject focus for primary teachers (for example, OFSTED, 1997), and to include more discussion and collaboration in secondary science teaching (for example, Murphy et al,1995), there has been little change in teachers' approaches to science teaching.

The third main aim of this study was to investigate factors affecting children's attitudes to science. Since there were a large number of potential influences to be considered, the evidence from the present study is compared with that from the literature, in Table 8.1 overleaf.

The fourth aim was to determine the extent to which the change in children's attitudes may be causally related to changes in teaching style. Both the quantitative and the qualitative data analyses have suggested relationships between teaching style and children's attitudes, and it seems likely that a change in teaching style causes a change in attitude.

The final aim of the study was to consider what measures might be taken to remove or lessen the adverse impact of any change in children's attitudes. However, in the light of the evidence this aim now seems inappropriate, since it assumes that *all* such changes would have adverse effects, when in fact some of the changes that occur appear to be beneficial. In point of fact, it would be more constructive to focus on changes having positive effects and at the same time try to reduce or remove those having negative effects.

Table 8-1: Factors affecting children's attitudes to science: A comparison of the findings of the present study with those within the literature

Possible influence on attitudes	Conclusions reached as a result of reviewing the literature	Conclusions reached as a result of the present study
Age	Declines with age	Declines with age
Gender	Boys more positive than girls	Boys are more positive than girls in primary school, but at secondary school the differences are insignificant.
Ethnicity	Minority ethnic groups, particularly Asians may have more positive attitudes, but evidence is limited and conflicting.	Asians may have more positive attitudes to school but the sample was too small to draw any definite conclusions.
Socio-economic status	SES may affect attitudes, lower SES may have less positive attitudes. But evidence is very limited and conflicting.	SES affects attitudes to science, girls with lower SES are likely to have particularly negative attitudes to science.
Peer group influence	Limited evidence but offers strong support for influence of peer groups.	NA
Parental support	Limited evidence but offers strong support for influence of parents and home background.	NA
Classroom environment	Open-ended laboratory activity, greater pupil autonomy and pupil-centred approaches in an organised classroom setting have positive influences on pupil attitudes.	Greater pupil autonomy and pupil-centred approaches have positive influences on pupil attitudes.
Practical work	Enjoyment of science lessons is enhanced by the use of practical work.	Enjoyment of science lessons is enhanced by the use of practical work.
Collaborative or group work	The use of group work is enjoyed by children and improves motivation.	Collaborative activities are linked with more positive attitudes to science.
Curriculum or instructional variables	No definite relationships established.	The use of topic work at primary school, and separate sciences at secondary school are linked with more positive attitudes. The use of the CASE scheme is linked with more negative attitudes.
Teacher subject knowledge and confidence	Technical competence and teachers' own beliefs and expectations are believed to be important. Confidence was related to science knowledge, after some teaching experience confidence tended to improve. Pupils may be influence by teachers' subject knowledge and confidence.	Teacher science qualifications are less important than their views about how to teach science.
Teacher views on the nature of science	Still open to question in view of the small number of studies involving practising teachers.	Not apparently related to children's attitudes, but was found to be linked with teachers' stated approaches to teaching science, INSET and teaching experience.

8.3 Distinctive features of this study

8.3.1 METHODOLOGY

The methods used in any study will inevitably have a direct effect on the conclusions reached; methods of obtaining and analysing data will both affect the outcome.

To take methods of measurement first, it was pointed out in Chapter 4 that the majority of studies purporting to examine changes on transfer instead examined differences between unrelated groups. The present research has been able to compare the use of cross-sectional and longitudinal methods using the same group of children, and has been able to demonstrate that different conclusions are reached using these different methods (see Appendix 9). Thus, there are very few studies that have actually examined changes in attitude (or achievement) on transfer.

Secondly, the amount of change is very dependent on the methods used to measure the change: the wording of questionnaire items, the aspects of science surveyed, the use of cross-sectional differences or individual longitudinal changes, and the use of qualitative or quantitative methods have all been compared in this study, and all have important effects on the results.

If the data is treated as two cross-sections then, taking an average of the responses to all the 'enjoyment of science' items, the decline in enjoyment of science lessons is only 3%. However, as discussed in Chapter 4, the response depends on the wording of the questionnaire item, and this varies: the maximum decline for a single item is 10%, and the minimum is 4%. However, items concerned with practical work, also part of the 'enjoyment of science' scale, show an *increase* in positive attitudes of as much as 4%. Thus, even within the same factor, responses vary considerably.

The three 'attitudes to science' factors are closely related and each of these contributes to the overall 'science attitude'. However, each of these science attitude scales leads to different amounts of change on transfer. Changes in the difficulty of science scores are negligible (not statistically significant and a decline on average of 0.5%); and there is a 4% increase in the proportion of children who find science written work LESS difficult after transfer. Since each factor reflects an aspect of attitude to science, one could take an average of all the responses, when the overall decline on moving from years 6 to 7 is only 3%. Thus, stressing particular aspects of science lessons will lead to different responses.

The nature of the methods used in collecting the data also lead to different results. When the *longitudinal data* from the present study is used, and the analysis is of *changes* in attitude, it seems that for almost 80% of children there is no significant change in attitude to science on transfer. Changes occur for only a minority of children, some of whom become much more positive while others become more negative. The proportion whose attitudes *decline* is about 12%.

Within the present study the qualitative data indicates a rise of 8.8% in the proportion of positive remarks about science, and this is quite close to the increase of 9.3% in positive views about science suggested by the quantitative data. However, the same could not be said for the expression of negative feelings: here the quantitative data suggests that 12% of children become less positive about science, but the qualitative data finds an increase of only 0.06% in the proportion of children making negative comments. So, even within the same study, there may be considerable differences when different approaches are taken. Clearly, the nature of the measurement instrument has a tremendous effect on the response elicited.

It therefore seems that the idea of 'measuring attitude changes on transfer' is rather a simplistic one. The variations within this single study suggest that the wording of questions and the methods used in such investigations may have such large effects that the obtained measures of overall change may not be very meaningful, particularly if a small, or non-random, sample is used. Furthermore, the comparison of the changes on transfer and on moving to year 8 at secondary school suggests that the changes in enjoyment of science on transfer are not very different from those on moving between years.

Hadden (1981) used a similar approach to that employed in the present study, with a longitudinal cohort, and his conclusion was that there was approximately a 10% decline in positive attitudes on transfer. One could not really make a valid comparison between the two results for Hadden's research took place Scotland, and was carried out in 1981; since that time there have been substantial changes in the education systems in both Scotland and England, and in science education (see Chapter 1). Some of these changes in educational policy were intended to reduce discontinuities on transfer, and others were designed to reduce gender differences in uptake and interest in science. So some differences between Hadden's research and this much later study might be expected, and it is interesting that the two findings are so similar. However, in view of the methodological difficulties discussed above, this similarity may be purely coincidental.

Turning next to methods of analysis, and in particular to the use of controls, the lack of such control has been a feature of many past studies of attitudes to science (see Chapter 2). To deal first with the effects of attitudes to school: it was apparent from the literature review that attitudes to school were subject to many of the same factors operating in respect of attitudes to science, and earlier research had also indicated a strong link between the two. The present research has again demonstrated this strong link. Thus, to ignore the effect of attitudes to school when examining attitudes to science is likely to produce misleading conclusions. As regards the statistical methods used in reaching conclusions many studies have used simple bivariate correlations, thus ignoring the effects of *any* variables. However, the present research has demonstrated that many apparently statistically significant bivariate correlations become insignificant when the effects of other variables are taken into account. Thus, studies using such simple methods seem unlikely to lead to relevant conclusions.

To summarise, studies purporting to measure change in attitude on transfer may obscure rather than clarify such change. However, if a large, random sample is drawn, and the effects of multiple variables are controlled, then within the overall measured changes there are valuable comparisons that can be made. In the present study, since the same wording and methods are used with every child (and teacher) in the cohort, comparisons between different groups at different stages are likely to be relevant and informative.

It is these comparisons that are discussed in the following sections. Comparison of the significant variables for years 6 and 7 shows that while some factors are important in both years, there are other factors that seem to be specific to each particular year; such differences are helpful in pinpointing aspects of education which could be improved, and which children value and find enjoyable.

And, of course the factors that are significantly linked with changes in attitudes point to ways of improving the transfer process.

8.3.2 GENDER AND SOCIO-ECONOMIC STATUS

The present research has found that gender does not necessarily affect attitudes to science; indeed, after transfer the proportion of girls who enjoyed science was larger than the proportion of boys who did. Now, the majority of studies within the literature assert that girls are less positive about science than boys, but these studies have not taken account of other variables, notably, attitudes to school and socio-economic status (SES). On the other hand, research by Breakwell and Beardsell (1992) did take SES into account and found no significant gender difference in enjoyment of science, although since the sample was problematic the result could not be generalised.

In addition, various researchers have linked enjoyment of school and changes in enjoyment of school with SES (for example Barker-Lunn, 1971), and the present research has found attitudes to school to be one of the key factors affecting attitudes to science. Therefore, it is likely that SES will have an effect on attitudes to science. The present research finds that SES does seem to affect attitudes to science, and furthermore, that gender differences in attitudes to science seem to vary by SES. This is the first study in which evidence has been provided indicating that gender alone is not the important factor in attitudes to science, although it has been indicated in Mathematics (Fennema, 1996). The group most at risk, in terms of declining attitudes to science is the group of girls of lower SES.

The present research has also indicated that girls and boys from different backgrounds might find different activities motivating. Thus, the current focus on gender differences may not be particularly useful, and a more specific focus on the differing needs of different groups of children may be of greater value. This is an area where little research appears so far to have been done, and it would seem to merit further attention.

8.3.3 CLASSROOM ACTIVITIES AND THE TEACHERS

The use of more collaborative and less teacher-directed classroom activities has been advocated by many researchers (for example, Kyriacou, 1997; Solomon, 1994; White, 1988); this study shows that the use of collaborative approaches are significantly linked with more positive attitudes to science, and also that more teacher-directed approaches *may* affect the perceived difficulty of science (although this relationship had a low significance value, and the effect may be very limited). Thus, the present study provides evidence for the first time that changes in attitude on transfer are related to changes in these types of classroom activities.

Furthermore, this research also found that the amount of collaborative work in primary schools was usually much higher than in secondary school, while the proportion of teacher-directed work was lower. Therefore, the transfer from primary school to secondary school is likely to lead to an overall reduction in enjoyment and to a general increase in the perceived difficulty. This is, in part, what was found in the present study; there was a (small) decline in enjoyment overall, matching the fall in the amount of collaborative work, but there was no overall increase in the perception of the difficulty of science on transfer. However, although there was no *overall* increase in the perceived difficulty of science, those children experiencing greater difficulty were more likely to have reported an increase in teacher-direction on transfer. It has been suggested that there is insufficient challenge in the first years of secondary school (for example, Ponchaud, 1997; Galton et al, 1999; OFSTED, 2000) and it might be argued that this could explain why many pupils did not find science more difficult on transfer. However, the suggestion of reduced intellectual challenge on transfer is not in evidenced in the writings of this group of children; many children regarded the work at secondary school as being more 'advanced', 'complex', 'difficult', but at the same time easier to understand. Only three children said that science at secondary school was easier; similar observations were made by Sutherland et al (1996). Hence, it seems likely that the change in classroom activities may be partly responsible for the changes in attitude to science that have been observed, and so there is a need for a careful balance of collaborative and teacher-directed approaches in order to maintain both positive attitudes and improved understanding. This need to consider pedagogical rather than pastoral or curriculum changes has recently been suggested by Galton et al (1999).

Turning next to the importance of the teacher, although the literature has suggested links between children's attitudes to science and those of their teachers (e.g. Hallam and Ireson, 1999) the present research provides the first quantitative data to clearly demonstrate significant relationships between the two. At both primary and secondary school, the teachers' approaches to teaching were significantly related to children's attitudes to science. Children in year 6 enjoyed science more if teachers favoured a more knowledge-based approach, while children in year 7 enjoyed science more with teachers who took a more child-centred approach. Since a knowledge-based approach was more usual among secondary teachers and a child-centred approach was more usual among primary teachers, this finding indicates a preference among children for a teaching approach that combines a child-centred style with a focus on subject knowledge and understanding.

Such differences might have been expected in view of the historical developments in primary and secondary science education (see Chapter 1). The dominant role of the primary teacher remains that of class teacher (Alexander, 1994, p.16), with a focus on 'children rather than subjects', and 'learning by doing' (Alexander, op. cit. p. 22). The current findings, of a greater emphasis on child-centred approaches than on the subject knowledge in science teaching (expressed in the responses to the teachers' questionnaire), suggest that this view persists today. The link between this child-centred approach and the more process-based view of science for the primary teachers in this survey suggests a connection between these two in the minds of these teachers. The process view of science may be helpful to primary teachers in allowing them to see how their *perceptions of their role in teaching* fit with the *legal requirement* to teach science. But it may also be preventing them from moving beyond their historical role. Similarly, among secondary science teachers, the view that science courses are aimed at knowledge transmission persists, and the process approach is often regarded only as a more efficient means to acquire concepts (Gott and Mashiter, 1994). A more balanced view may be required, as indicated by the children in this study. Such a view requires considerable encouragement and support through ITE and INSET.

In their written comments many of these children said they preferred science after transfer because their primary teachers did not have sufficient science training or understanding of science. They also referred to the increased opportunities for their own experimental work, which they regarded as allowing them greater autonomy. These children were clear, in questionnaire responses, in their writing and in interview, that individual or small group practical work was rare at primary school. Now, Harlen and Holroyd (1996) and Watt (1996) have indicated that teacher confidence (closely linked with subject knowledge) has an affect on the nature of classroom teaching; teachers with weaker subject knowledge being likely to close down activities in order to stay within the bounds of their subject knowledge. In addition, the children in this study have indicated that they have more opportunities for practical work at secondary school because they have more knowledgeable teachers. The increased use of practical work has generally been attributed solely to the improved facilities at secondary school, but the present research suggests that it might also result from having teachers with greater technical competence and confidence. On the other hand, this study demonstrates that children's attitudes to science are related to teachers' feelings about science and their approach to science teaching rather than to their science qualifications. This suggests that a focus on subject knowledge in ITE may not be particularly helpful in changing teachers' classroom approaches and their personal views of science. Subject knowledge is clearly an important aspect; but teachers need to develop an understanding of what science is about, and also to recognise the importance of a balance of process and content in their approaches.

8.3.4 Schemes of work

This study has suggested that using particular teaching schemes at secondary school may have an important effect on children's attitudes to science. The use of a 'separate sciences' scheme seems to have a positive influence, but the use of the CASE scheme appears to have a negative influence.

When a 'separate sciences' scheme is used chemistry is taught as a separate subject, and there are clear indications in the children's written responses and interviews that the 'chemistry' topics were the most enjoyed, once at secondary school, and the most anticipated while at primary school. Newton & Newton (1998) found that the majority of children included chemical apparatus in their drawings of scientists. This fascination with 'chemistry' is interesting, and it might represent a stereotypical view of 'science' as portrayed on television (Newton & Newton, op cit.). However, this research suggests another possibility - that these children regard chemistry as more exciting than other aspects of the curriculum, perhaps because it can be 'seen' and appears to be less abstract. Children appear to regard chemistry as a subject offering more variety and more opportunities for practical work than any other science. Although later in their secondary education these children may change their opinion of chemistry, in year 7 this appears to be how they see it.

The present research has found that children in schools using the CASE scheme had less positive attitudes to science than children in the other schools surveyed, and that their attitudes declined more than those of children in other schools. The reasons for these findings are as yet unclear. The CASE schools in this study appear to differ from the other schools in the sample in that they may be in more disadvantaged areas and their intake populations may have lower abilities, as measured by CAT scores. These differences may account for the present findings. Nevertheless, the girls, but not the boys, from poorer backgrounds seemed to have less positive attitudes to science when using this scheme, and these differences may be important. However, these effects of the CASE scheme on attitudes were discovered because some of the survey schools simply happened to be using this scheme; but these schools had not been specially selected, and they may have been unrepresentative of schools using the CASE scheme. Thus, it would not be justifiable to make assumptions about the value of the CASE scheme on the basis of these findings. As yet there is no research into the effects of the CASE scheme on attitudes to science, using a properly representative sample of schools.

8.3.5 TRANSFER STRATEGIES AND LIAISON

Liaison arrangements vary from school to school; but interviews in primary and secondary schools indicated excellent levels of pastoral support, and evidence from the children suggests good curriculum continuity. However, as already indicated, for many children there appear to be abrupt changes in the classroom activities employed by the two sectors and in the teachers' approaches. Although some of these changes do enhance the enjoyment of science, if the aim is to provide continuity in the terms suggested in Chapter 1[1], then schools should turn their attention to what has been called the nature of the learning experience.

This research has indicated that the way secondary schools use transfer information may influence changes in attitudes to science. Pupils are significantly more likely to find science more enjoyable and less difficult after transfer if they move to secondary schools that regard the primary transfer information as valuable. A positive and constructive approach, by secondary schools, to the use of transfer information from primary schools have been encouraged over decades (e.g. Plowden, 1967; SCAA, 1996), and should help schools and teachers to provide differentiated teaching and learning. The differences observed between

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[1] As Jarman et al suggest *...consistency in aims, values and expectations, but not uniformity of experience, and it [continuity] suggests that there are no sudden changes in the nature of the learning experience without good reason,* (Jarman et al, 1994).

primary and secondary schools about the relevance of transfer information need to be resolved if all children are to find the move from primary to secondary school challenging, but not de-motivating.

8.4 Future work

The relationships between gender, SES and attitudes to science clearly require more detailed investigation. Gender and social class were linked through the analysis of both the quantitative and the qualitative data, but this link remains tentative and more work needs to be done in exploring this area. Two studies would seem appropriate: a quantitative study relating attitudes to science with individual home background information, taking account of ability; and a qualitative study of representative individuals from the quantitative research, focusing on why they hold particular attitudes.

Since there is, as yet, no research into the effects of the CASE scheme on attitudes to science, this also seems to be an area, which would benefit from further investigation. Such research should have particular reference to gender and social class, since girls from poorer backgrounds might have less positive attitudes to science when using this scheme. This seems to be particularly important in view of the apparent lack of consideration by secondary schools as to which scheme of work might be most appropriate to the children transferring from primary school.

Thirdly, there are two methodological issues arising from this research that may be of particular interest: a re-analysis of the present data using multi-level modelling, and a validation of the Views of Science questionnaire for teachers.

Although it was not possible to use multi-level modelling at the time of this research, a new analysis of the data using this technique might lead to further clarification of the effects of the transfer process. The Views of Science questionnaire could prove a very useful tool, once validated. It could be used in assessing pre-service teachers' views about the nature of science prior to and after their teacher education courses. It would also allow a further attempt at investigating the relationship between teachers' views of science and children's own attitudes and views about science.

Although the county of Essex is representative of England in many ways it has a lower than average proportion of ethnic minorities within its population, and so the present research was not able to reach any reliable conclusions about the attitudes to science of ethnic minority pupils. This is a further area where there has been little research, and more work would be valuable. Moreover, longitudinal studies of transfer in a wider context than Essex: in large cities, in different parts of England, and in other countries, could yield a different picture, and would certainly give greater insights into the effects of background, school and teacher variables on children's attitudes to science at transfer.

Despite the many survey studies of attitudes to science there is still a need for further research at the macro level since much of the earlier work has failed to control important variables, particularly at transition. Thus, research at the micro level is often carried out without theoretical underpinning from reliable and recent macro work. Until the potential effects of changes in macro conditions at transition are better understood, the value of micro studies in this area remains limited.

Finally, the present study has suggested that the teachers' views of science may be dependent upon their perception of their role, and upon their age, experience, or gender rather than their subject knowledge and these are also areas that deserve attention by future researchers in science education.

8.5 Suggestions for professional development

Some children took the view that primary science was inferior to secondary science, and that their primary teachers lacked the specialist scientific knowledge necessary to teach science. When this perspective is combined with the secondary science teachers' distrust of the transfer information that they receive, and the difference in views between primary and secondary teachers of what were important aspects of science and science teaching, then the result is likely to be a belief among secondary teachers that the children coming from primary school had acquired less knowledge and understanding than was actually the case. This in turn is likely to lead to a lack of challenge in the work being set at secondary school.

However, the opposite scenario is also possible: namely that the link between greater enjoyment and greater emphasis on the transmission of knowledge at primary school indicates that these children want to be given factual information and theory, and that their primary teacher's emphasis on a skills-based approach may be less appropriate for these children in year 6. Furthermore, there are the primary school teachers' own comments: these suggest a lack of confidence among many, and this may not lead to science teaching at the appropriate level. So it is probable that for some children the transfer to secondary school leads to a great increase in difficulty.

Thus, there appear to be three groups of children: one group who are insufficiently challenged on transfer, another for whom transfer offers a sufficient increase in challenge, and a third group for whom the challenge is too great.

Part of the remedy for this problem lies in the hands of the secondary schools; a greater trust in, and reliance upon the transfer information as a means to construct a challenging syllabus rather than as an aid to organising ability groups is clearly required. In addition, confidence building remains important for primary school teachers. This might be best achieved by providing more science INSET opportunities for all primary teachers, particularly aimed at developing practical skills and a deeper understanding of the nature of science. The need for links between the teachers in the two sectors remains important; but the emphasis should move from *what* is being taught to *how* it is being taught.

The emphasis on the 'how' rather than the 'what' is also important for particular groups of children. This study has indicated that girls from less affluent backgrounds might be particularly at risk, and also that, in general, boys' attitudes to science declined more than those of girls. Once at secondary school, girls were particularly likely to comment on perceived improvements in learning, i.e. on clearer explanations at secondary school and on the opportunity for more challenging work. Thus, the opportunity to do more practical work is unlikely to provide sufficient encouragement for girls; they need to feel challenged by the level of the work and to feel that they are being offered clear explanations. However, boys seem to be enthused by practical work and by having a variety of learning approaches.

In poorer areas greater use of computers in science may well be helpful, particularly to boys, as an aid to producing better quality written work, and to linking theory and practical work in a more stimulating way.

All these are matters that would merit consideration in future CPD programmes.

8.6 In conclusion

The current emphasis on testing ignores the importance of attitudes. It is clear from the results of GCSE examinations that attainment in science continues to rise, in particular for girls; and yet the uptake of science courses in FE and HE remains low. In some subjects, such as physics, it is actually falling, and girls remain less likely than boys to continue the study of science beyond 16, thus demonstrating that more high grades in science exams do not necessarily lead to a greater uptake of science studies beyond 16. The research literature indicates that achievements in Key Stage tests and GCSE examinations are closely linked to socio-economic factors: children from poorer backgrounds are likely to do less well in such tests, and there has been no noticeable improvement in this situation since the introduction of the National Curriculum. Evidence from the present study suggests that the attitudes of children from these same backgrounds, to both school and science, are likely to decline more than those of children from more affluent backgrounds, and they are particularly at risk of losing interest in science. However, changes in teaching approaches on transfer could encourage more positive attitudes.

As discussed in Chapter 1, attitudes to science are important; unless children have positive attitudes to science they are unlikely to choose to study it beyond GCSE. Attitudes appear to decline year-on-year with the age of the child, and yet most of this is a general decline in enjoyment of school. Attitudes to science remain more positive than attitudes to school for most children of this age. But there is a steady falling away, which is a much larger issue that still needs to be addressed.

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