The Implementation and Impact of the Secondary Science National Strategy:

A single-school case study to explore the changes in classroom teaching styles and the responses of students to these initiatives

A thesis submitted for the degree of
Doctor of Education
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October 2010

Abstract

The National Strategy for Science was progressively introduced from 2002 with the intention of providing a clear structure for improved delivery of the subject in secondary schools. Through a series of scripted training events, supported by printed resources, the intention was to provide science teachers with a clear framework for sequential teaching of key themes through the use of pedagogy intended to involve the students in their own learning.

After several years, the nature of the National Strategy shifted to concentrate on the support of subject leaders, and the Strategy is planned to end in 2011. The current school cohorts have all experienced the teaching of science since the introduction of the Strategy, and should therefore have benefitted from the improved delivery, intended to create improved outcomes and more positive attitudes towards science.

By means of a case study investigation in 2008 in a single school, the impact of the National Strategy was explored. By means of a range of qualitative methods, including questionnaires, interviews and lesson observations, it was possible to investigate the extent to which National Strategy ideas had become embedded in the daily routines of the science teachers, and the extent to which students viewed science positively. The study focused on Y7 (soon after entry to the school), Y9 (prior to the SATs examinations) and Y11 (during the run-up to GCSE).

An initial study four years previously was used to provide an indication of changes during the life of the Strategy, and to indicate trends. In addition, sampling in other schools was used to determine whether the questionnaire results were atypical.

The results showed that the Strategy had largely failed to become embedded in normal classroom practice, with little evidence of teachers making good use of the pedagogy or the structured delivery that was central to the Strategy message. The reasons for this failure were:

- The expectation that centrally-delivered training would be effectively cascaded by one individual to other teachers in the school,
- The failure to concentrate on a few simple messages or themes, repeatedly delivered and reinforced in subsequent training,
- The introduction of a plethora of other initiatives, each demanding teacher time, and diluting efforts to focus attention on the National Strategy themes.

As a result, the science teachers in 2008 showed less understanding of the Strategy than teachers in 2004, and their use of techniques such as the three-part lesson and enquiry-based learning were less evident.

The Strategy was to be a mechanism to improve examination results and to improve student attitudes to science. The examination results are shown to be largely stagnant over this period 2003-2008, and the attitudes of students towards science are shown to become less positive during their time in secondary school.

The key finding, therefore, is that the Strategy failed in its aims because it failed to listen to its own message. It failed to recognise that teachers, just as much as students, need simple messages, repeatedly delivered in innovative ways, in order to learn and fully internalise these ideas.

Acknowledgements

This research would not have been possibly without the assistance and encouragement of many people. First and foremost, the students and teachers of the case study school proved to be eager participants and a mine of invaluable information. They may never know the wealth of their contribution and their insight, but their words are forever captured in print. In particular, the headteacher, Peter, was a great support and personal friend.

I would also wish to thank my supervisors, Prof. Mike Watts and Dr. Sue Collins of Brunel University; without their prodding this work would have been unfinished in the face of the pressures of ‘the day-job’. Their professional discussions, advice and deadlines will always be remembered.

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Abbreviations and acronyms used in the text

A level	Advanced Level General Certificate of Education (generally taken at age 18)
DCSF	Department of Children, Schools and Families (2007 - 2010)
DES	Department of Education and Science (1964 - 1992)
DfE	Department for Education (1992 - 1995; and 2010 onward)
DfEE	Department for Education and Employment (1995 - 2001)
DfES	Department for Education and Skills (2001 – 2007)
GCSE	General Certificate of Secondary Education (generally taken at age 16)
ICT	Information Communication Technology
NFER	National Foundation for Educational Research
Ofsted	Office for Standards in Education (regulatory and inspectoral body)
QCA	Qualifications and Curriculum Authority (1997 – 2010)
QCDA	Qualifications and Curriculum Development Agency (2010, short-lived)

CHAPTER 1 Background to the Study

This chapter explores the rationale behind the research and how it came to be conducted. The National Strategy for Science was a major initiative, growing out of the UK government's Key Stage 3 Strategy and which in turn grew from the National Literacy and Numeracy Strategies. These major initiatives involved training, resources and funding, aimed to address specific issues within the UK education system in the early years of the 21st Century. The research was triggered by a sense of unease at local authority level in that the exciting and innovative work, so well received by teachers, appeared to have no lasting legacy.

1.1 Overview

This study has aimed to explore the impact of the National Strategy for Science by concentrating on the local effectiveness and the changes that resulted from the introduction of the Strategy in one school. The chosen school is typical of secondary schools – in so far as this can be said of any school – and the case study may therefore have relevance in other schools and may reflect trends seen in the national picture. Certainly, there is nothing about the chosen school to suggest that it is atypical of the majority of schools in the UK (see Appendix 1).

The investigation intended to examine the Strategy outcomes by exploring the extent to which they had become embedded since its launch in 2002, and the extent to which the main purpose – more positive student attitudes to science – have been achieved. It was impossible to do this in a purely quantitative approach, since the student population was constantly changing, as were the teachers and the wider society. In addition, attitudes to science are generally difficult to quantify and are affected by external factors beyond the school. The study therefore involved a number of sources of information, some partly quantitative, but most essentially qualitative. The aim of this diversity was to triangulate data and in so doing provide a structure for the validity of any claims.

The overall purposes of the study were threefold. First, there has been no comparable study of the grassroots impact of the National Strategy for Science, despite the massive investment in finances, resources and time. Previous studies of the impact have been at the level of national data, gathered in the form of outcome statistics from examination results, or have been at the level of brief reports by consultants. The former lack individual detail, and the latter lack robustness. Neither of these methods have explored student attitudes to any great extent, and tended to focus on directly measurable outcomes. There is a gap in our understanding of impact at the level of individual students. This gap extends to the early development of attitudes during Key Stage 2, and the implications of these hardening attitudes during Key Stages 3 and 4. By the time that students make decisions about further study in Key Stage 5 and at university entrance, the implications of positive or negative attitudes towards science will be of life-changing importance. The government has commissioned the National Foundation for Educational Research to conduct extensive surveys of student attitudes towards science over a period starting in 2009, such is the level of concern.

More surprising is how little empirical research has been done into the impact of classroom innovations on the confidence, motivation and performance of students in English schools.

> There have been relatively few projects which have systematically evaluated the impact of their work at student and classroom level... …the fine-grained analysis of the impact upon teaching and learning is absent... Much of the current school improvement practice assumes that all strategies are equally effective for all schools… Harris (2000, pp.7, 9)

This may be a reflection of lack of innovation in teaching methods until the introduction of the National Strategies in primary schools, and later, in secondary schools. Much existing comment (e.g. see references: Guardian 20 June 2003; TES 14th December 2007; BBC 24th February 2010) has been anecdotal, and reports opinions and experiences without a basis in research.

The second purpose of the study is to understand the successes and failures of the Strategy, and to draw from this some guidance on how best to meet the demands of science teaching in the next decade, where government and industry recognise the need for more science graduates (see Science and Innovation Investment Framework 2004-2014, 2006). In a general context where students increasingly turn their back on science qualifications – seen as being too difficult and uninteresting – there is an urgent need to employ sharply focussed strategies to improve student attitudes.

The third purpose is a professional one. As a Senior Adviser working for a local authority, it would be easy to assume that my own impressions, and those of other workers in the field, are a true representation of what is going on in schools. This study is therefore an opportunity to explore whether these professional views are supported by a rigorous and detailed exploration of the situation in a case study school.

In addition, the level of investigation implicit at EdD level is important in terms of personal and professional development, to enter this rewarding arena of research into education. As a professional teacher and adviser, little opportunity is presented for reflection and research, and this doctoral thesis has been the first foray into a broader review of educational change.

1.2 Significance of the Study

The National Strategy for Science is one of a number of initiatives that have been introduced into schools in the last decade. These new initiatives have included new approaches from the Department for Education and Skills / Department for Children, Schools and Families (DfES / DCSF), and new syllabus and assessment models from examination boards, under direction from the Qualifications and Curriculum Authority (QCA). In addition, external 'whole-school' initiatives have impacted on the way that schools operate.

It would be difficult to mention all of the initiatives and changes, but recent and current examples have included, amongst others:

- Assessment for Learning
- Assessing Pupil Progress
- Every Child Matters
- Condensed Key Stage 3
- Personal Learning and Thinking Skills
- Big Picture of education
- Changes to GCSE and A level syllabuses
- 14-19 Diplomas
- Outdoor Classroom
- One-to-one tuition
- Expanded use of ICT (Information Communication Technology)
- Workforce reform
- Dropping Key Stage 3 National Tests (SATs)
- National Challenge and Gaining Ground schools
- School Improvement Partners
- Specialist School status

- Self-Evaluation Form

In addition, in science teaching there has been a recent focus on:

- Level 6 Plus
- Triple Science
- Core and Additional Science at GCSE
- Applied Science
- Science Learning Centres
- How Science Works

Each of these initiatives, rolled out with promotional material and funding, has involved schools in considerable effort to implement the required changes. While some of the changes are described as ‘non-statutory’, the majority of schools have adopted each in turn as the school is encouraged to conform and make use of available budgets. The various initiatives have been disruptive to the school organisation to a greater or lesser extent, and have invariably saddled classroom teachers with additional work in order to adapt their practice to meet new demands.

The pressure to adopt the initiatives has come from the government, but also from local authorities and neighbouring schools. However, many of the new initiatives have been hastily introduced after a brief but well-funded pilot trial in chosen schools (eg. Hallam, Rhamie and Shaw, 2006; DCSF, 2009; DCSF, 2010). The evidence for the long-term benefit of each initiative is often sketchy at best.

The introduction of new initiatives has not, publicly at least, been associated with clear explanation of the outcomes expected from the initiative by itself. While schools have overall targets, the impact of the initiative at a local level, and separated from the impact of other concurrent initiatives, is never clear to the teachers involved in the classroom. As Friedland (2005) terms it, the initiatives have no Results Accountability at a local level:

> If we knew what outcomes we wanted and how to measure them, the next logical thing to do would be to assess how we are doing on each of the measures. We would then forecast ….. whether things were likely to get better or worse if we just kept doing what we were doing (p.6).

Although an individual teacher may not be involved in all of these initiatives, the cumulative impact of the changes, in creating a constant sense of turmoil and uncertainty, has caused a sapping of energy and less enthusiasm for innovation (Ofsted, 2010; see also referenced BBC News 24 Feb 2010).

> ...the sheer number of initiatives and programmes and the speed at which schools are expected to implement them may be counterproductive (OECD 2008, p.144).

In addition, the impact of this overload has often resulted in two outcomes whereby schools effectively act to minimise the trauma of endless change:

- Superficial and temporary engagement with the initiative, such that the changes are not embedded or developed to their full potential. The initiatives are often dropped or at least reduced as soon as another initiative is introduced.
- Box-ticking: providing minimal evidence that the initiative has been ‘done’ in order to satisfy monitoring bodies and obtain necessary funding.

The National Strategy continues to be the greatest influence, and has become the delivery agent for many of the subsequent initiatives. The Strategy initially concentrated on subject strands in Key Stage 3, but in 2003 the focus shifted to whole-school approaches (see DfES 2003, i, ii) and later the National Strategy expanded to include Key Stage 4.

The Strategy was introduced in 2002, in response to recognised problems in Key Stage 3 (Years 7–9, ages 11-14). These problems were perceived to be a lack of progression and loss of motivation in many students of this age, with particular worsening towards the end of National Curriculum Year 7 and throughout Year 8. The disappointing performance at Key Stage 3 had been highlighted by improvements in Key Stage 2:

> The success at primary level over the last two years has brought into sharp focus the unacceptable lack of progress from age 11 to 14 (Blunkett, 2000, online).

Ryan (2002) discussed some of the current understanding of the reasons behind this dip. She identified factors that may play a part in the overall problem at transition:

- Changes in curriculum structure – new subjects and different teachers
- Changes in the style of language used
- Changes in teaching and learning styles
- Changes in environment – both the school itself and the learning base
- Time constraints in secondary schools
- Variation in primary schools, requiring topics to be retaught to secondary classes
- Lack of awareness by secondary teachers of what is taught at primary school
- Changes in attitudes and motivation during adolescence

The DfEE (later DCSF) had long recognised the existence of a problem within Key Stage 3 (the ‘Forgotten Key Stage’). The causes of these issues were numerous and interwoven, but the central issues were felt to be a lack of planned progression in schemes of work, and overly didactic teaching methods. As a result, pupils who had made good progress through their primary schools were suddenly encountering traditional teaching methods that lacked individual engagement, and were often repeating work with which they were already familiar. Thus, “…the dominant experience in Year 7 is really one of repetition of work rather than true progression, as some research suggests…” (Braund and Driver, 2002, p.5) Faced with this, it was widely recognised that students were becoming disillusioned and sometimes poorly behaved.

> Research commissioned by the DfEE helps explain this poor performance. Achievement slips in the transition from primary to secondary schools. Too little is expected of pupils in the first year of secondary school, by the end of which around a third of pupils perform worse in tests than they did a year earlier. (Blunkett, ibid. online speech).

The expenditure on the National Strategies has been immense. The overall figure, taking into account the gradual shift in the focus of the Strategies and the expansion to include other subjects and age-groups, has been as follows:

2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
£425m	£465m	£335m	£410m	£460m	£470m	£420m	£450m

Table 1: Annual expenditure on the National Strategy (source: DCSF)

The issue reported in many schools is that when the focus shifts from one initiative to the next, the previous initiative declines in importance and many of the advances are lost. The lack of sustained pressure on a small number of proven ‘high-impact’ strategies appears to have led to a general failure to make progress in England and Wales. This lack of progress can be seen in the limited change in the examination outcomes since the introduction of the National Strategy for Science:

		2002	2003	2004	2005	2006	2007	2008
Science	Level 5+	67	68	66	70	72	73	71
	Level 6+	34	40	35	37	41	40	41
English	Level 5+	67	69	71	74	73	74	73
	Level 6+	32	34	34	35	34	33	33
Maths	Level 5+	67	71	73	74	77	76	77
	Level 6+	45	50	52	53	57	56	57

Table 2: Percentage of students achieving Level 5 and 6 in National Tests (SATs) at Key Stage 3 (age 14)

(source: national data releases)

Thus, in the years since the initial launch of the National Strategy for Science in Autumn 2002, the performance of students has increased 3% at Level 5+ and 1% at Level 6+ between 2003 and 2008. Given that the Strategy would have taken time to have an impact on teaching and hence results, the change attributable to the Strategy effect is less than this, possibly amounting to zero.

It is possible that the contribution of the National Strategy may be seen in areas other than examination results, for example in promoting student interest in science, encouraging uptake post-16, and supporting the work of less-qualified teachers in a period of staff shortages. The impact (or otherwise) of the Strategy cannot be judged by examination results alone.

My research looked at the impact of the Key Stage 3 Strategy for Science in 2008, exploring and evaluating the extent to which the considerable effort and expense had brought about embedded and sustained change since the introduction of the National Strategy in 2002. The focus of the research was on the effectiveness of teaching in stimulating the interest of students throughout their secondary science education, and in particular explored the way in which teachers used the pedagogy central to the National Strategy to engage with learners.

The significance of the research was thus to indicate whether fundamental change to teaching practice can be instigated by intense effort over one or two years, or whether a longer-term approach is required to bring about embedded and sustained developments. Evaluations have tended to be in the form of annual reports, often focussed on the apparent stagnation of national examination results in all three Core Subjects over the last five years. The National Literacy Strategy (NLS) and the National Numeracy Strategy (NNS) were evaluated in 2002 (DfES 2003: iii), at the time that the Science Strategy was being introduced. This report noted that results in Literacy and Numeracy had improved, but "… much of the increase occurred prior to the introduction of the NLS in 1998 and NNS in 1999…".(p.3) The same report noted that:

Although the Strategies have made a good beginning in a relatively short period of time, the intended changes in teaching and learning have not yet been fully realised. After four years, many see NLS and NNS as needing to be re-energised; the early momentum and excitement have lessened and a new boost would be helpful (DfES, 2003: pp.8-9).

This being the case after four years, it would be important to consider whether the same issues are true in science – whether the early impact in 2002-2004 in changing teaching styles was indeed sustained after a further four years without a re-energised approach and where other initiatives have taken centre-stage.

The wider question, therefore, was whether embedded changes in education can be driven by short-term initiatives, or whether systemic change requires a sustained focus on an objective for possibly a decade, in order to overcome the inherent resistance of the status quo.

1.3 The End of the National Strategies

The National Strategies are set to end in 2011, which for the Science component is nine years after the introduction and initial roll-out. The decision to end the programme was motivated by two factors: the economic downturn has made the financing of the Strategy hard to afford, and the stagnation of the results has made the Strategy hard to justify (see Table 2). This decision to terminate the funding for the Strategy was not known at the time of starting this research, though the Strategy was always seen as time-limited.

Against this backdrop, a number of decisions have been taken which would suggest to an observer that science has become less important in the school curriculum. For example, science will have no national testing at Key Stage 2 (Y6, age 11) from 2010 and testing was dropped in Key Stage 3 (Y9, age 14) in 2009. All achievement targets that included science have been dropped, and the remaining target is the number of students gaining five or more GCSE passes at A*-C grades, including English and Mathematics. At all levels the importance of English and Mathematics is stressed, and Science barely registers as a ‘Core Subject’ in the curriculum.

Despite this, all political parties indicate their continued commitment to science, and the need to produce new generations of qualified scientists. The numbers of students taking A-level courses in mathematics, chemistry and physics are monitored in National Indicator 85, part of the reporting process between local authorities and the Government (see DCLG, 2007).

It is quite clear that the National Strategies failed to lead to a breakthrough in examination outcomes (see section 1. 2) and as such the commitment of significant funding and effort could be seen as doing nothing more than arresting further decline in attitudes towards science. However, this begs the question about the introduction of initiatives without sustained drive and without considering the impact at a local level – in this case at school level.

This research seeks to explore some of the issues, and to evaluate the impact of the National Strategy in one case-study school.

1.4 Rationale – contextual framework

The effectiveness of schools has been a concern for over 200 years – from the Parliamentary Committee on the Education of the Lower Orders in the Metropolis of 1816 through to a succession of committees and reports since the late 1960’s. All too often the prime influence on children turned out to be social background. Despite a stream – and more recently a flood – of education initiatives and reorganisations, the effectiveness of schools has risen only slowly. At different times, both locally and nationally, it has been fashionable to blame teachers, senior leaders, pedagogy and student behaviour. Outside of schools, the roles of parents and wider society have also been under the spotlight. The publication of *Fifteen Thousand Hours* (Rutter *et al*, 1979), coincidentally in the year when I started teaching, claimed that schools could make a real difference, despite the social background issues such as deprivation, gender, ethnicity and prior attainment. Since that date, the flow of educational ‘interventions’ has accelerated, until schools are now reaching ‘initiative overload’. This phenomenon is widely reported in research and in the press (see OECD 2008; other citations listed under Other Sources in References). The difficulty has been that new policies and approaches are never fully embedded before the focus moves on to other areas, and the effectiveness of each change is rarely evaluated in detail. ‘The research is proceeding, but so is the implementation of new policies, and the latter usually leave the research behind’ (Shipman, 1997). It appears to schools that the new ideas are often based on political beliefs and timescales, rather than on educational research and piloting trials.

In parallel with these issues of school effectiveness, there has been a growing concern over the attitudes of society towards science. Once seen as a great and worthwhile endeavour, science has increasingly fallen from favour in the media of more economically developed countries, and scientists are often portrayed in popular culture as socially inept figures. This issue is explored in detail in Chapter 2 but suffice to say here that school children of all ages will rarely state that they see a scientific career as attractive.

In addition, it is often forgotten that teachers, while members of a profession, are to an extent working in isolation. In the past, many teachers worked behind closed doors, a law unto themselves, and often mildly idiosyncratic in style. This state of affairs resulted in a very varied use of teaching methods and inconsistent effectiveness. Until recently there was little sharing of practice or systematic observation of teaching, and only with the introduction of Ofsted inspections did this situation begin to transform. Indeed, it required further guidance to begin to reintroduce variety into approaches (Ofsted 2009) and reduce uniformity.

While this state of classroom isolation may now be less common, teachers may or may not be influenced by the practice of their departmental colleagues, the whole school context, surrounding schools, and national guidelines. Of these successive layers of influence, the closest and most influential is the department. The close-knit teams of 5-10 science teachers are ideally placed to develop their own common styles and techniques, becoming ‘Communities of Practice’ (Wenger, 1998). As stated by Donnelly (2000, p.271) ‘…the experience of being a science teacher varied markedly across these schools.’ These communities often become resistant to change and invest in the establishment of their own expectations, methods and resources. “Pedagogic technique may show considerable stability” (Donnelly, ibid., p.272). The adoption of new practice has to overcome the inertia of embedded systems, and the management of change depends on the vigour and interpersonal skills of key players in the department.

1.5 Research Questions

The research explores four linked questions, which are central to an evaluation of the National Strategy for Science. The impact of the Strategy could be deemed successful if it had a sustained legacy in any of the following three aspects:

- Improved examination outcomes for a significant number of students, potentially leading to higher uptake post-16 and into Higher Education
- Changes in teaching styles leading to greater engagement of the students, greater interest in science, and greater understanding of concepts
- More positive attitudes towards science, amongst students and wider society, and thus a greater willingness to consider further study or employment in scientific areas.

The first aspect has been studied in detail, and as yet there has been no profound change in the examination outcomes at age 14 or 16. The uptake into post-16 science courses has shown little change, although the decline is less steep than previously. The other two outcomes have been less studied, and this research considered these aspects.

Research Question 1:
To what extent have the teaching methodologies promoted by the National Strategy become embedded in the everyday practice of teachers?

Research Question 2:
To what extent do students relate positively to these methods?

Research Question 3:
Have student attitudes to science become more positive since the introduction of the Strategy?

Research Question 4:
To what extent can any change be attributed to the National Strategy approaches?

All of these questions were initially explored in 2004 employing a wider context of other schools, where comparative data were collected by questionnaire surveys. The case study school, Ashbourne School, was included in the Phase One research, and the findings from 2004 could be compared with the Phase 2 case study in 2008, as well as compared between schools. In 2008, the questions were then investigated in greater depth in the context of a case study in a single school, using qualitative approaches. This second phase of the research permitted a comparison of changes over time, as well as allowing a focus on issues raised in interviews.

In order to answer these research questions, it was necessary to consider how to pose subsidiary questions in order to generate the answers. In many cases it was necessary to isolate the potential impact of the National Strategy from many other contributory factors linked to changes in teaching during the period of the research.
Bouma (1993) discussed the general form of hypotheses where X causes or is related to Y but, in this research, such linkages are less well defined. The case study revealed emerging issues and posed new questions to explore as the research developed but, at the outset, the general hypothesis was that the National Strategy had an impact on student learning and attitudes to science. Within this hypothesis, there were general questions:

- Which aspects of the National Science Strategy do teachers recognise and employ in their lessons?
- Do students benefit from the teaching methods advocated by the Strategy, and have these methods had a measurable impact on their performance?

These general questions were explored through a series of more specific questions, aimed at providing data to support or refute the hypothesis in the case study school.

The specific questions included:

- Do teachers identify new techniques stemming from the Strategy training?
- Do teachers implement these techniques in the majority of their lessons?
- Do teachers believe that the methods improve the learning process?
- Do all members of the department uniformly apply the new methods?
- Can teachers identify, and possibly quantify, improved student performance?
- Do students find science lessons stimulating and relevant?
- Do students recognise any increase in confidence and motivation in science?

By considering these specific questions within the context of the wider general proposition that the National Strategy would have a discernable impact if delivered within a school, the main research questions could be answered. These subsidiary questions thus provided areas to consider during the interviews and observations.

The case study school could be placed within the process of school improvement described by Huberman and Miles (1984) where a cycle of transformations would lead to a series of outcomes. Unusually, the decision to adopt the National Strategy and the process of adoption and support were all made externally, at national level. The teachers within each school may or may not have endorsed the imposed strategies, and possibly may have sought to avoid or subvert any changes to the status quo. If teachers (and in particular, the Head of Department) did not ‘buy into’ the ideas of the National Strategy, then the implementation will have been inconsistent and less effective. The study needed to recognise that the impact on students may be reduced if teachers are applying the approaches reluctantly.

Because of this, the attitudes of the teachers towards change, and to the National Strategy in particular, were important factors to consider in the discussion of the outcomes.

Allied to any consideration of the effectiveness of the National Strategy for Science, it is necessary to explore whether the success or failure of the Strategy is fundamentally linked to wider issues. These would include whether it could ever be possible to present the subject in a way attractive to the majority while simultaneously providing the in-depth approach needed by the few students wishing to take the subject in the Sixth Form and at university. This vexed question – Science for All or for Just a Few? – is explored in Chapter 2. The National Strategy essentially took the position that particular approaches could improve the attitudes of all students towards science, while an increasing body of research indicated that the situation was vastly more complex.

Data sources for research questions (all data collected in 2008, unless specified)

Research Question	Data Collected	Form of Analysis	Linkages
1 To what extent have the teaching methodologies promoted by the National Strategy become embedded in the everyday practice of teachers?	• Teacher interview • Lesson observation • Student interview • Student questionnaire	• Thematic reduction and coding • Data reduction and concluding • Thematic reduction and coding • Numerical and coded analysis Comparison of experiences of teachers and students.	Verification (Miles and Huberman 1984: 22) and triangulation (Silverman 2000: 177). Comparison with 2004 Phase One research interviews and questionnaires.
2 To what extent do students relate to these methods, and benefit from them?	• Student interview • Student questionnaire	• Thematic reduction and coding • Numerical and coded analysis Comparison of themes and issues raised in data sources.	Cross-reference and exploration of issues depth in interviews. Comparison of three different age groups.
3 Have student attitudes to science become more positive since the introduction of the Strategy?	• Teacher interview • Student interview • Student questionnaire • Phase One questionnaire 2004	• Thematic reduction and coding • Thematic reduction and coding • Numerical and coded analysis • Numerical and coded analysis	Axial coding (Strauss and Corbin 1998: 124). Comparison of student and teacher experience, and changes since 2004.
4 To what extent can any change be attributed to the National Strategy approaches?	• Teacher interview • Student interview • Teacher interview 2004 • Phase One questionnaire 2004	• Thematic reduction and coding • Thematic reduction and coding • Thematic reduction and coding • Numerical and coded analysis	Comparison between views of teachers and students, comparison between 2004 and 2008.

Table 3: Data sources

1.6 Terminology

Spanning as it does a period of great change, this research bridges changes in terminology within and outside the teaching profession. Some of the terminology is confusing as it changes over time and some terms are little used outside specialised contexts.

The governmental department dealing with education has evolved from DES (Department of Education and Science) to DfES (Department for Education and Skills) and then to DCSF (Department for Children, Schools and Families) – see http://www.dcsf.gov.uk/index.htm for details. The changes within the government structure have not been relevant to the research question. Coinciding with completion of the research, the title of the department changed again – to DfE (Department for Education). Throughout the text, the appropriate name is used where possible. For example, throughout Chapter 2 the DfES is referred to as this was the title in use at the time of the literature review.

The launch of the National Strategy at first included Literacy and Numeracy, but the expansion to include other subjects introduced the name ‘Key Stage 3 National Strategy’, which in turn evolved into the Secondary National Strategy as the target cohort moved into Key Stage 4. Throughout this document, the term ‘Strategy’ is assumed to include the science component of the Secondary National Strategy, and the term Strategy is used for brevity. For details of the Framework for the National Strategy, and its revised form, see: http://nationalstrategies.standards.dcsf.gov.uk/node/16078?uc=force_uj for an outline.

The terms Key Stage 3 and Key Stage 4 refer to units within the school systems of England and Wales, referring to ages 11-14 and 14-16 respectively. The school years within these Key Stages are referred to as Year 7, Y8, Y9 in Key Stage 3, and Y10 and Y11 in Key Stage 4. In most areas of the country, these correspond to the years of compulsory secondary education, with Year 1 to Y6 (KS1 and KS2) being primary education, and Y12 and Y13 (KS5) being post-compulsory education.

The introduction of new terminologies, linked to new initiatives, can be related to changes in Government and the respective ideologies. The National Curriculum, which determined what is to be taught in schools, was introduced in 1988 by the Conservative Government, though it has since been through a number of revisions. The National Strategy was a product of the Labour Government, and was introduced into Secondary schools in 2001 / 2002, following the introduction of Primary National Literacy and Numeracy Strategies (NLS and NNS) in 1998 and 1999 respectively.

The STEM subjects are those covered by Science, Technology, Engineering and Mathematics. It is a government target to increase uptake of STEM subjects in schools.

The QCA (Qualifications and Curriculum Authority), which became the QCDA (Qualifications and Curriculum Development Agency), was responsible for producing non-statutory schemes of work, widely used in schools.

Throughout the text, following Ofsted practice, the term ‘student’ is used to refer to schoolchildren of secondary age (11-18 years old), while ‘pupil’ is used to refer to schoolchildren of junior age (7-11 years old) and ‘children’ for infants aged 5 to 7. In some cases, quoted text and references may not follow this convention.

1.7 Brief account of each following chapter

Chapter 2:
This chapter explores the literature which informed Government thinking at the time of the introduction of the National Strategy for Science, and which has subsequently explored the ongoing debate about the purpose of science education – and its shape for the future. The chapter identifies the influences on policy-makers and on students, and recognises the lack of specific analysis of the impact of the National Strategy at school level.

Chapter 3:
This chapter considers the research methodology to be used, and explains why the case study was chosen over other possible forms of research. The chapter also considers the philosophical position adopted, and considers how this stance is in line with much current research at grassroots level.

Chapter 4:
In this chapter the results from the questionnaire, student interviews, staff interviews and lesson observations are considered in turn, identifying the key issues revealed in each and demonstrating how issues raised in one line of research were explored further in the other lines, thus allowing each to inform the other. In this way, the outcomes of the research were correlated and issues were contextualised.

Chapter 5:
Here the outcomes are discussed, to locate meaning in the data and to consider where there are answers to the research questions posed.

Chapter 6:
In the final chapter, the work is summarised and conclusions are drawn, seeking to demonstrate how this research may be further developed. Where appropriate, recommendations are put forward, suggesting how better to implement educational change, and how student attitudes to science might be improved.

1.8 Professional Experience

After some twenty years in the classroom, I felt that I had a clear understanding of how students view science and what works well in lessons to engage interest and stimulate participation. Equally, I had an awareness of the typical limitations in average schools with average teachers. It is frequently a challenge to integrate pedagogical methods recommended by external agencies, when getting through the teaching day is the first concern. There is an additional burden of 'initiative overload', where new ideas and policies need to be adopted in quick succession without time to embed previous concepts. Hess (2005) refers to "…the longstanding persistence of oversold educational innovation, almost none of which has yielded significant reform". In consequence, many teachers in Britain are resistant to change and suspicious of new 'fixes' to ongoing problems. Ellsworth (2000) describes this general phenomenon by using the categories of resistance described by Zaltman and Duncan (1977); in most schools it is possible to recognise some or most of these characteristics. As Richardson (1998) states:

> Teachers often resist change mandated or suggested by others, but they do engage in change that they initiate… …voluntary change.
>
> (downloaded article, no page ref.)

Having seen these issues at first hand, I also recognised that each school operates in a degree of isolation, with little opportunity for intimate cooperation and sharing of practice. Even where this occurs, each school has its own ethos and atmosphere, making the experience of students very different from one institution to the next. The separate subject departments in a single school invariably show differences in approach and effectiveness, often linked to the vigour and experience of the subject teachers. In consequence, schools – and departments within schools – become small communities of practice (see Wenger, 1998), resistant to externally instigated change.

As a teacher in this arena, and more recently as County Adviser for Science and finally as Senior Adviser (Secondary Manager), it is easy to recognise the need to establish the impact of new policies as each is introduced in turn. The frequent failure of Central Government to evaluate policies at school level may have contributed to the stagnation of results despite a massive investment of time, energy and funding, since the successful strategies are not sorted from those with little impact. This thesis seeks to fill the void by exploring the embedded impact at classroom level of the main strategy affecting science teaching since 2002.

1.9 Link to Portfolio and IFS

The portfolio component of my doctoral work was an opportunity to explore initial ideas and to trial both questionnaires and interview questions. The results from this trial work were valuable in several respects. They helped to sharpen the research questions by removing a number of ideas that proved to have little basis. The trials also revealed interesting aspects to the data, following work in a number of different schools.

The results showed remarkably little difference between schools, or between groups within the same school. This was unexpected, since it was known that the schools had a different ethos, and the teaching styles were quite contrasting, if not idiosyncratic, from one school to another. Despite these differences, the students had statistically significant similarities in their views and preferences.

The trials in 2003-2004 included, by chance, the school later chosen for the main research. This provided an unanticipated opportunity to compare results between 2004 and 2008, thus giving a longitudinal view as well as corroboration of trends.

Interviews of teachers in 2003-2004 also provided a snapshot of the development of the National Strategy in its early days, when relatively fresh, heavily promoted, and central to much of the thinking in schools. This made a striking comparison with the main research in 2008, after the first waves of training had passed, and during a period of consolidation.

The Institution Focused Study (IFS) component of the EdD was an opportunity to explore the influences on Government thinking at the inception of the National Strategy, and to consider the ways in which student needs and attitudes were taken into account in the development and direction of science education. This research, exploring literature and the various arguments, forms the core of Chapter 2. A number of issues raised in this review of literature form the basis for further exploration in the main research.

1.10 Literature

The teaching of science, and the changing attitudes of students towards the subject, have been the focus of much research over the last century. Indeed, it is one of the curriculum areas where most research has been conducted, and differing views stemming from the research have been the instigation of numerous attempts to improve or change the way in which science is taught.

However, very little research has been done to investigate the implementation and impact of these initiatives. Changes are introduced into schools, often based on ideas that ‘work’ in one context, but are shown to have little impact when applied to other situations. A good recent example is the SEAL (Social and Emotional Aspects of Learning) programme, which has been shown to have relatively little impact in some situations (Humphrey et al., 2008).

This illustrated a gap in the literature for science, where no case studies have explored the long-term impact of the National Strategy for Science at school level. The existing literature has tended to focus on overall evaluations, where possible, and the changes at classroom level have been ignored in most studies.

The literature quoted in this research is largely bounded by the following:

- Time – essentially post-2000 and in particular related to the science Strategy since its introduction around 2002,
- Place – the literature relates to England and Wales, the nations where the Strategy has been implemented,
- Subject – the focus is on the Science component of the National Strategy.

1.11 Political Influences

This research is indirectly influenced by national and local issues, and while every effort is made to distance these influences, it is inevitable that there will be an impact on the methodology and the interpretation. Recognition of the political dimension is essential in protecting the research from these external pressures.

The most obvious political influence is exerted by the Government, through the DCSF and the National Strategy organisation, in seeking to find positive outcomes from the implementation of the Strategy. This is particularly acute at the time of General Elections and during bidding for the National Strategy contract. It was very noticeable that pressure to find evidence of impact of the Strategy increased after the initial few years, with less emphasis on pedagogy and more on collection of raw outturn data – Local Authorities were asked to report quantitative outcomes in terms of examination results and levels of attendance at meetings, rather than qualitative changes in attitudes or engagement.

A second area of influence has been the stated view of politicians that education outcomes are concrete and measurable, with an ongoing demand for ‘facts’ rather than philosophical uncertainties. There has been a sharp dismissal of discussion of theory, and a demand for reporting in terms of positivistic outcomes that apply in all situations. While this may play well in the political arena, when engaging the electorate, those closer to schools and students would often have some difficulty with this position. This issue is further discussed in Chapter 2.

1.12 Link between Research Focus and Ethics

The choice of a Case Study approach was made for several reasons. First, the method was appropriate for the research aims, and was able to provide data within the time available.

The second reason was pragmatic. The opportunity to work in the school was possible through my normal links with the school, and it was possible to carry out the work through an extension of the routine relationship between the Local Authority and the school. The research could thus be carried out without any risk of intrusion into the life of the school. The teachers were interviewed without affecting their role in the school, and the students were interviewed without any disadvantage to their studies. The research period was brief, and all work was agreed in advance with the school, the teachers, and with the students.

The ethical considerations were paramount at all stages, and total anonymity was ensured throughout. Transcripts could not be linked to individuals, and all video recordings of interviews were erased. The final description of the research could not be linked to a particular school, and only those teachers involved in the interviews were aware of the process.

Administration and Ethics

The research mechanism was restricted by protocols of access to schools, child protection, and the professional relationships that exist between the researcher and the researched. Permission to work in the school was obtained from the Local Authority and from the Headteacher, and agreement was sought from the teachers in the science department. Finally, permission was sought from the students prior to any activity involving them as individuals (as in interviews).

The ethical considerations within case study research are considered by Punch (2000) and each key aspect was considered, as follows:

1. *Informed consent*: The research and the intended outcomes were fully discussed with participants when seeking their permission to gain access to the school, the students, and records.
2. *Privacy*: Interviews were conducted in offices or vacant rooms where the process was free from disturbance and could not be overheard. Experience from the initial Phase One interviews showed that this is not always easy to achieve, but it was essential that participants were able to relax and express their opinions openly.
3. *Confidentiality and anonymity*: From the outset, the school and the participants were given an absolute assurance that the research details and findings would not be attributable to the institutions or participants involved.
4. *Access and ownership*: The research was shared with the school and the participants, and they were invited to suggest corrections where factual errors had been recorded. However, the findings were not altered in cases where the validity of the research would have been threatened.
5. *Use of results*: The research will not form part of any Local Authority review of the school, and will not be used to influence any allocation of funding or resources. Where matters arise, it would naturally be quite difficult to separate this from the routine collection of information about each school, but the issue of equity was fully recognised.
6. *Honesty and trust*: The researcher has a very good relationship with the school and the staff, but nevertheless it was explained at the outset that the school or individual teachers were able to withdraw from the research if at any time they felt that trust had been breached. Equally, it was hoped that participants would be open and honest during the research, as otherwise the findings would be invalid.
7. *Reciprocal benefit*: The report was shared with the participants and, with their permission, shared with the Headteacher. Where issues suggest improvements, the report may benefit the school.
8. *Harm and risk*: In any study involving employees and children, the absolute and fundamental concern is that the researcher should do no harm. The professional experience of the researcher ensured that participation in the research presented no risk, and at all times this was a critical consideration.

1.13 Limitations

Despite the unfortunate expression ‘Bog Standard Comprehensive’ used by the Prime Minister’s spokesman Alistair Campbell in 2001 and by the then Education Secretary, David Blunkett, in 2005, the reality is that no two schools are alike in detail. In fact, schools have surprisingly little in common even when organisationally they may appear similar. The social and economic background of a student - combined with the choices of their peer group – often plays a far more important role in determining what subjects they study than the type of school they attend. This is well-documented, as for example in Osborne *et al* (2003), citing Lemke (2001):

> …it is no longer tenable to imagine that engaging with science is an equivalent process for all, demanding only logical thought and application, and that, rather, cultural and class difference may be a significant aspect in many students' attitudes towards science (p.1073).

In view of this, it is accepted that a case study is strictly meaningful for the particular school and the particular students, but may have limited applicability in wider terms. However, the research may serve to illuminate issues and confirm theories in other institutions.

It is also recognised that a case study of this type can only reflect the views of teachers and students at one point in time, and cannot reliably indicate how their views have changed over time. A longitudinal study, observing the changing attitudes of individuals, would best reveal the impact of National Strategy teaching styles but at the risk of the research itself influencing the outcomes. No single approach is free from limitations, and the depth of a case study was judged to be most effective in reaching valid conclusions from a dynamic context.

CHAPTER 2 Review of Literature

In reviewing the literature related to the introduction of education initiatives, and in particular the effectiveness of the National Strategy in developing positive attitudes in students of secondary age, it rapidly became necessary to write a paper within a paper. The study of the literature and the associated legislation became difficult to isolate from the in-school research, particularly where new developments and announcements from the Government took place during the study period, effectively changing the dynamic of the research itself. For this reason, the literature review was in the form of an institution-focussed study, where the institution was the DfES (now DCSF). This enabled the review to concentrate on those parts of the literature extant at the time, which influenced the thinking of the Government department during the introduction and later evaluation of the National Strategy for Science. The issues related to student attitudes to science, in Britain and in the rest of the World, have been studied in depth, with contrasting conclusions in many cases. By locating the review of literature within time boundaries (2000-2008), it was possible to identify the relevant studies and exclude those which did not relate to the National Strategy. The literature review came down to a single critical question:

Science for All or for Just a Few?

This question seeks to identify whether it is possible to teach science in secondary schools with the twin aims to provide a grounding in scientific literacy for all students, while also preparing a minority for further study of the subject in much greater depth. This issue has been the source of much debate, and conflicting solutions have been suggested at various times and by various groups. This literature review explored the information and influences imposed on the Department for Education and Skills (DfES) in the early years of the 21st Century, as it sought to provide improved science education and position the UK workforce to meet current and future demands for science expertise.

2.1 Introduction

For the two decades 1988-2008, the UK Government had set as an utmost priority the development of a world-class educated workforce, able to compete effectively in the developing global marketplace. The slogan “Education, education, education” was coined in 1997 for the incoming government. Traditional markets and competitors in Europe were steadily replaced by the rising Asian ‘Tiger Economies’, and the position of Britain as a knowledge-based economy had been challenged by new players. The DfES sought to address the failings of Science teaching in England for the last 25 years, but by the time of this research had yet to find a formula that provides in-depth knowledge for the few who will continue to study science, while at the same time providing an engaging and relevant science education for the majority of students who will use this knowledge in everyday contexts.

This review of literature evaluates the issues and the sources of information that influenced the direction taken by the DfES/DCSF in attempting to address the critical issues that will ultimately determine the long-term success of the nation. Inevitably, some of these influences on the DfES had been well-researched and were open to critical review. Other influences, from the public, from politicians and from industry were less well documented and were rarely subject to research above anecdotal level. These influences were challenging, since they were powerful agents on the DfES, but are poorly recorded.

A primary finding from this review was that many of the factors present in the British education system were actually features common to all More Economically Developed Countries (MEDC), to similar degrees. These factors included declining attitudes towards science at school, and a generally poor impression of scientific careers. These attitudes worsened progressively from late primary age, and were not related to gender, ethnicity or socio-economic factors.

A second finding was that students and schools recognised that science subjects are more difficult, and lead to lower average outcomes at A level.

> At A-level, the STEM subjects are not just more difficult on average than the non-sciences, they are without exception among the hardest of all A-levels.
> (Coe *et al*, 2008 p.2)

This was a disincentive to further study and served to add to the existing low take-up in Key Stage 5 stemming from the poor attitude towards science subjects.

A third finding was that the quality of information available to the government varied from rigorous peer-reviewed academic studies at one extreme to anecdotal, politically-driven statements of opinion at the other extreme. The bulk of literature, much of it in professional journals, was based on small-scale research or personal experiences. In consequence, decisions of the DfES were often in reaction to vocal lobbies, and reflected pragmatic responses to social realities.

The attempts by the government to blend applied, contextual and relevant scientific literacy for the masses with a detailed academic scientific training for a few has not been successful to date, since teachers limit their teaching to accepted traditional factual content:

> Currently, the majority of science teachers consider it their role to present the ‘facts’ of their subject and not to deal with associated social or ethical issues. (Wellcome Trust, 2001, p.7)

2.2 Context

The developing Education System in Britain in the years immediately after the Second World War began to recognise the universal importance of science in the lives and careers of the population. The initial structures arising from the 1944 Education Act did not ensure science for all, but it was an increasing feature of Grammar schools. The widespread arrival of comprehensive schools in the late 1960’s and early 1970’s, following Government Circular 10/65, enabled all children to access science at school. The final step was the introduction of the science National Curriculum in 1988 which defined the content that all students should be taught.

Throughout this transition, and up until the present day, there was strong discussion about the purpose of science education and whether current provision suits all outcomes. The British Government recognised the need to provide a workforce with suitable skills, and responded to concerns and pressures within and outside the education community. The purposes of school science education, and the accepted rationale behind it, were questioned by some authors (eg. Chapman, 1991) and the essential justifications were systematically thrown into doubt. However, despite Chapman’s cogent argument, the aims and justifications presented by the DfES are the accepted orthodoxy or ‘institutional truth’.

The issues faced by the DfES were, and still are, truly international (Sjøberg and Schreiner, 2005 ii) and the following review of literature recognised this, but concentrated on the British context, specifically the education in England and Wales. The review was also bounded in time-frame, being concerned with the steps taken to produce a ‘21st Century’ workforce and in particular the changes introduced since 2001. The date 2001 is significant because it marked the formulation and earliest introduction of the pilot Key Stage 3 National Strategy for

Science, and with it new approaches to teaching the subject. This new set of pedagogical techniques drew on the need for greater engagement and involvement, and indicated the need to move away from the traditional didactic teaching methods. This change hinted at a re-evaluation of the purpose of science teaching, and recognised the failings of what had gone before. For this reason, sources dated 2000 onwards were used where possible.

2.3 The Nature of the Dilemma

The purposes of science education can be defined in the following ways:

1. **Utilitarian**: The function of science education is to enable all citizens to cope with and understand the environment in which they live. This is essential ‘science for life’ and provides a basic knowledge about everyday household and workplace science.
2. **Scientific literacy**: This aspect of science knowledge provides an understanding of current issues such as global warming and GM foods. The purpose is to enable the citizen to make informed choices and understand the background to the issue. This concept is disputed by many (eg. Black, 1993).
3. **Cultural**: Much of 21st Century Western culture is defined by the influence of science and technology. Without an understanding of the origins and influences of scientific thinking and advances, the citizen would be unable to relate fully to the surrounding culture.
4. **Economic**: Opportunities for employment in Developed Economies are less related to manual manufacturing roles, and are increasingly related to the research and development of scientific and technological products. A higher level of scientific knowledge provides the citizen with access to these areas of scientific employment. (see Science Education Forum: Work-related Learning in Science, 2006)
5. **Applied research**: Linked to the developing technological economy, there is an expanding need for research into the application of scientific ideas, methods and products into the national productivity. This role has traditionally been a strong feature of many Pacific Rim nations.
6. **Pure research**: The development and expansion of scientific knowledge without immediately obvious commercial applications is an area of research endeavour for which science education at school level provides the initial grounding.

(adapted from Millar, 1996)

The debate on the future direction of science education at secondary school level hinged on the essential balance of these purposes. On one side of the debate, science taught in Key Stages 3 and 4 (age 11-16) should provide detailed academic training to support progression into Sixth Form (age 16-18) and Higher Education courses, leading to scientific research and careers. However, only a small minority of students passing through this regime would make use of their learning, and many more may have become ‘turned off’ by the traditional academic approach. The DfES Five Year Strategy for Children and Learners (2004) recognised that the current provision was ‘fundamentally elitist’. Ten years previously, Black (1993) had indicated that changes in science, in education (pedagogy), in society and in the students themselves would all require a deeper consideration of this direction for science teaching in schools. It was therefore ironic that the defence of the status quo – a broadly academic Double Award GCSE, with three separate science courses for more able or motivated students – was itself the subject of much debate when introduced in the mid-1980’s. This was discussed by Daniels and Bell (1989). Their concern was that schools failed to adopt Combined Science, which brought together and integrated the three traditional science disciplines, and instead maintained ‘specialist teaching’ at GCSE level. In other words, the schools continued to make use of graduate teachers to cover the sciences in which they held particular interests and experience, rather than force teachers to cover unfamiliar subject matter. The way in which many schools recognised and defended the traditional three sciences was noted, and the DfES came full circle in raising the profile of

Triple Science (i.e. the three sciences) in the Science and Innovation Investment Framework 2004-2014 (HM Treasury, 2006). This strategy was seen as providing the students with an adequate grounding for further study of science.

The other side of the debate identified the need to provide the bulk of the population with essential basic scientific knowledge – functional scientific literacy – and advocated a more engaging approach which looks at current social and environmental issues from a scientific perspective. This concept did not provide the requisite grounding for further study in the subject, but did at least maintain the interest of the students. However, much of the science and technology central to these issues would be far beyond the level taught at school, and it might be argued that 'a little knowledge is a dangerous thing', in that decisions would be taken from insecure understanding. The National Science Teachers Association in the USA made a policy commitment (Beyond 2000,NSTA 2003) to achieve scientific literacy for all students, recognising the changing knowledge of the natural and technological world, the changing knowledge about how students learn science, and the growing place of enquiry skills in the essential science content. That this policy should build so heavily on the British model (Beyond 2000, Millar and Osborne, 1998) is no surprise. The issues in science education are largely global, and there is general agreement within the educational establishment as to the problems and the future direction to be taken. However, these views are not necessarily shared outside the education system.

This discord reached a crisis with the universal introduction of new GCSE specifications in 2006, within weeks of the new courses being introduced. This issue was discussed in the House of Lords, contrasting the desire that '…all pupils be entitled to learn the three separate science up to GCSE…' against the limitation that '…far too many students in comprehensive schools are still being taught science by teachers with no specific science qualifications…' (ParliamentToday, 25th October 2006). There is here recognition that the new courses did not offer the depth of study required by a few students.

These new courses encouraged a questioning and exploratory approach, rather than simple learning of established scientific concepts and knowledge. This change from a didactic approach was highly significant, since 'telling' rather than 'discussing' was a feature of science teaching in the past, and was a feature seen in primary schools in most if not all countries (Alexander, 2001). The content-driven teaching at secondary level had traditionally been even more teacher-led and with less student-focus. Thus, the move away from the volume of knowledge previously demanded at this level was an acceptance that a flexible, adaptable workforce and society would be of more use than a society locked into the fact-base of the previous generation. Indeed, it was widely accepted that the current generation of schoolchildren would need to know less about science as they would be overwhelmingly users of technology, rather than creators of it. Chapman (1991) argued that most users of computers, for example, had absolutely no need to know how a microprocessor works. This 'de-skilling nature of technology' has continued exponentially since he wrote this phrase a decade and a half ago. For example, very few people in Britain will now attempt to repair their car, or even carry out routine maintenance. Increasingly, such tasks are left to a very small number of specialists.

There was, and still is, great difficulty in resolving the best path to adopt, when the research and voiced opinions are rarely impartial and are frequently influenced by the stance adopted by the authors. For example, Daniels and Bell (1989) refer to the aims of the DES (which later became DfES) in their Science 5-16 statement (DES, 1985). They noted with regret that the aims of the changes, and the implementation of Combined Science, were being subverted by the schools. Despite being a relatively small-scale sample of 120 schools, and based on a questionnaire survey, the results identified by Daniels and Bell were in agreement with general perceptions at the time and likely to be broadly accurate. The important contribution of this research lay in the documentation of falling rolls, reduction in group size, and the loss of variety in the science courses on offer. Twenty years on, the situation looked very different. Class sizes became larger, in part because of a science teacher shortage, and the government now saw variety of provision as being more ‘personalised’ than the ‘bog-standard comprehensive’ model from the 1990’s. However, the damage done in changing direction yet again was that schools could no longer provide the specialist teaching that would now be in vogue (Smithers and Robinson, 2005).

Caught in the middle, schools and students responded as best they could to the immediate pressures upon them. For example, the documented difficulty of science subjects (Fitz-Gibbon, 1999) made further study of science unattractive and unrewarding for students, despite the ‘….higher quality of life and a higher expectation for salaries…’(ibid.). Schools, faced with league tables (School Performance Tables) reportedly tended to discourage students from embarking on study of low-performing science subjects, since the lower results will have had a negative effect on the school’s Average Point Score.

2.4 Influences on the DfES

The Department for Education and Skills was at the centre of a hub of influences and pressures, each offering different analyses of the current position and attempting to determine future directions. The DfES offered a pivotal role in setting the policies and resources which in turn directed the way in which schools would provide teaching. The Department was thus able to manipulate classroom delivery.

The DfES, being a government department, was strongly influenced by the political flavour and pressures from ministers. As a result, the decisions taken by the DfES were often directed by powerful Think-Tanks and pressure groups of MPs. In some cases these influences reflected extreme views and positions that were far from the mainstream of the educational establishment. However, these initiatives often created a climate of change and an environment where the paradigms could shift as the status quo is challenged. For many schools, the political interference was unwelcome and contributed to ‘Initiative Overload’.

The DfES was also subject to political pressures derived from the economy, with the CBI and other groups raising concerns about the availability of qualified scientists and the level of investment into research and development in science and technology. These concerns focused on the current economy as well as looking forward into the future.

A second pressure on the DfES came from the discussion about the purpose of science education as an issue in secondary schools. The rationale behind current practice, which stemmed from the perceived needs in the 1950s, was being challenged. The aim to educate an academic elite to a high level of scientific knowledge was accepted, but the associated attempt to train the whole population to the same standard was being questioned, and it was generally accepted that the average citizen would be unlikely to call upon much of the science that they had learned in school. If the underlying purpose of a science education was being reconsidered, then the DfES was obliged to respond to this. The need for greater flexibility in the system was recognised in the Five Year Strategy (DfES, 2004), where it described ‘taking a system designed to deliver a basic minimum entitlement and elaborating it to respond to these increasingly sophisticated (and rapidly changing) demands.’ In other words, the DfES recognised the need to create a more adaptable workforce and a more flexible curriculum structure.

A third pressure on the DfES, demanding a review of current provision, had been from secondary school students. Feedback from students, whether informal or as part of rigorous research, had indicated a level of disenchantment with existing content and presentation of science in secondary schools. The views of students were further compounded by their perceptions of future career aspirations and employment possibilities. In general, students in

Developed Economies did not see science as an attractive arena, offering the type of prospects that would interest them (see Sjøberg, 2004).

The fourth influence on the DfES arose from changed views about teaching styles. The general pattern of teaching in had seen a marked shift from didactic to student-centred methods, with more emphasis on questioning and individual research. This had in itself encouraged students to reject the formal delivery of scientific knowledge in favour of topics where there were more opportunities to engage with the learning. These changed expectations in both teaching and learning had challenged the traditional view of science as a body of facts to be transmitted to following generations. The DfES acknowledged this change, and further encouraged it, with the introduction of the Key Stage 3 National Strategy (now called the Secondary Strategy) in 2001.

Finally, the DfES was obliged to consider the views of society, and with it the current interests and future needs of the nation. The guidance for schools, directly and indirectly, had reflected the concerns and aspirations of the Press and powerful lobby groups. For example, the role of animal dissection had greatly diminished, and the use of hazardous chemicals had been strictly controlled or banned. Fieldwork had become less common, largely through concerns about safety of students. At the same time, pressure had been mounting for greater ‘relevance’ in the syllabus, with the inclusion of topics such as Genetic Engineering and Global Warming. These changes had, in the most part, been opposed by the scientific establishment where these new topics replaced more traditional knowledge.

Key influences and interactions on decision making by the DfES

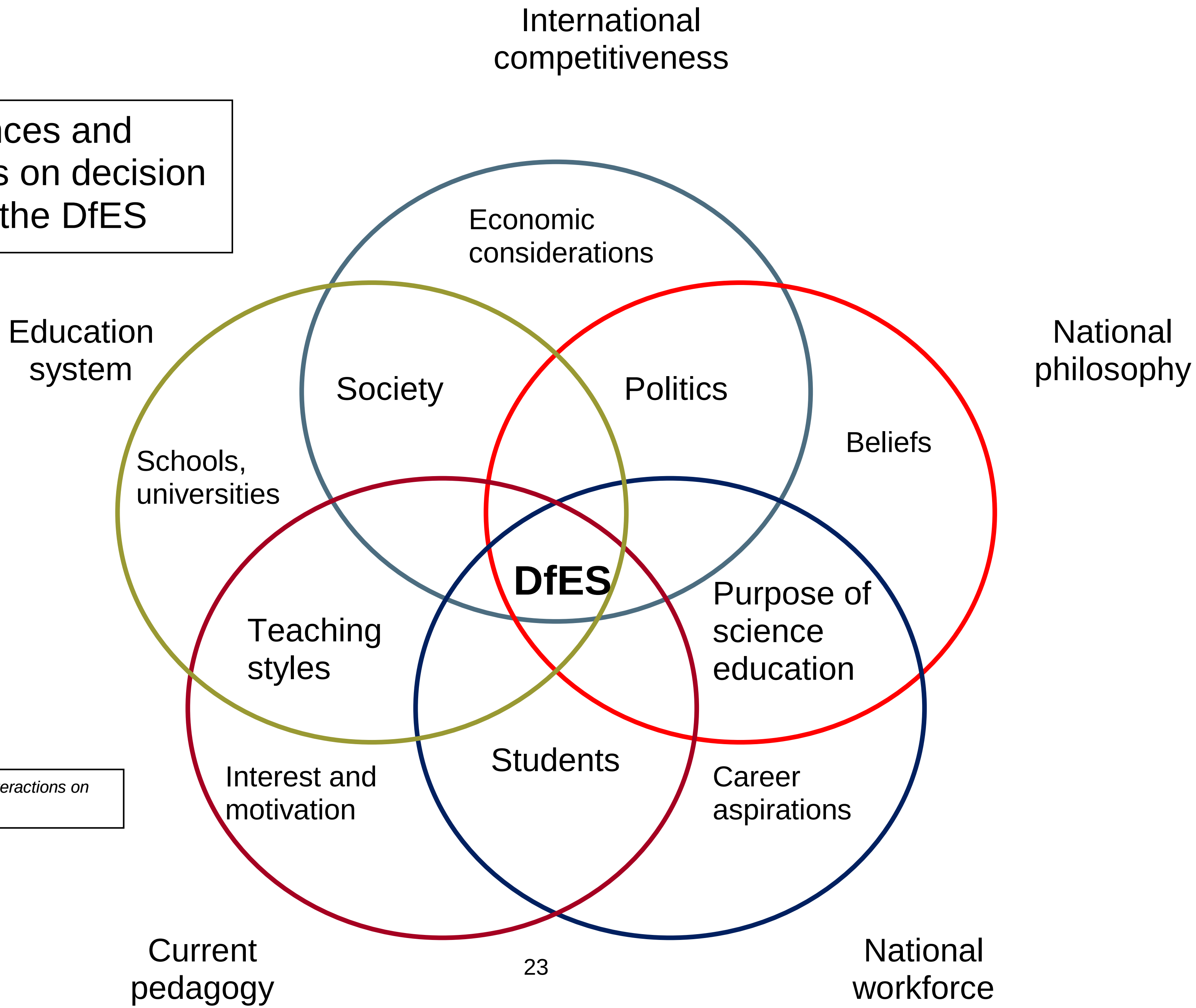

Figure 1: Key influences and interactions on decision making by the DfES

2.5 An examination of the evidence and literature available

(a) Student attitudes: a Global issue

Amongst the literature citations, some pieces of work have been particularly significant. Osborne *et al* (2003) reviewed the range of literature published on the topic of student attitudes towards science, and considered the basis for tackling the problem. While this paper was written some time after the DfES had commissioned the National Strategy to address the issues, the authors were able to summarise the arguments that gave impetus and direction to the Strategy. In the years since this paper, critical new research (eg. Jenkins and Nelson, 2005) confirmed and developed the findings.

The concerns about the form and direction of science teaching in schools have been debated for a considerable period. As far back as 1842, the engineer George Stephenson warned that ‘British industry was in danger of falling behind its competitors’ and in 1854 Herbert Spanner argued that science was the most important knowledge to have (quoted in Chapman, 1991). These same concerns were raised throughout the following (20^{th}) century, and alongside this was the issue of student attitudes. The increasing rejection and unpopularity of school science was noted by Ormerod and Duckworth (1975) and had worsened in the 30 years since then. Reiss (1993: p.11) described a situation where “many pupils quite correctly feel alienated from school science and drop it once they can.”

In addition to being a historical issue, these concerns were, and still are, also global. Much of the evidence for student attitudes being wider than national or local characteristics had been anecdotal, and verified by minor studies (Oversby, 2005). The most significant attempt to collate international student opinion has been through the ROSE project (Relevance of Science Education) (Sjøberg and Schreiner, 2005). This major study, based in the University of Oslo, made a significant contribution to knowledge about the issue, with over 40 countries taking part. However, the method of data collection had significant aspects requiring deeper consideration. For example, the core instrument for gathering data was a questionnaire survey, illustrated in Schreiner (2004). The use of a single questionnaire format for widely different nationalities and cultures had many advantages, in allowing statistical comparisons between the various groups of 15 year old students. However, the method was also problematic in that the students in such diverse parts of the World, including a number of relatively less economically developed nations, had different relationships with the process and the questions set. Not only was their ability to interpret the questions based on their own experience and educational background, but the students also had different understandings of their role in the World. It was also inevitable that the nature of the questions, being closed questions (see Oppenheim 1992, p.112) for a Likert-type response, suffered from being often ‘leading’ (Cohen and Manion, 1989) and shallow, without an opportunity for in-depth analysis of the views of the students. An example of a problematic question is illustrated by:

D10: People should care more about protection of the environment

(Sjøberg and Schreiner (2005: ii), slide 27)

Depending on the background of the student, the ‘environment’ could be interpreted in a local or global dimension, and the statement clearly encouraged an affirmative response. Jenkins (2006) noted that the ROSE questionnaire did not define ‘science’ or ‘technology’, and that these terms had different connotations in different countries. These issues, and the significant problems of interpretation, were recognised and discussed by the authors of each national study and by the project leaders. For example, the results from England (Jenkins and Pell, 2006) were based on 1284 returns from 34 schools - a 60% return from schools invited to participate. The schools were initially chosen to reflect the variety of school types and social contexts within England, but the authors could not control the 40% of schools that failed to return the questionnaires, leading to under-representation from London, and other statistical anomalies. Presuming that this type of issue was widespread amongst the other participating countries, the results could not be claimed as totally representative of students in a local or regional sphere. Indeed, the Japanese study (Ogawa and Shimode, 2004) fell below the minimum number of students, and the 560 responses from 19 schools could only be considered to be a case study, rather than a representation of the national cohort. Despite the concerns about the validity of some aspects of the ROSE data, the conclusions drawn were certainly in agreement with the anecdotal experiences of teachers and researchers. The summary of key issues presented by Sjøberg (2004) reflected the views of most students in Britain.

The ROSE project was not the only source of comparative international data. The Third International Mathematics and Science Study (TIMSS, more recently referred to as Trends in Science and Mathematics Education)(see TIMSS 1999 summary), and the OECD Programme for International Student Assessment (PISA) both suffer from many of the same methodological and philosophical issues, and the three ongoing studies focus on different aspects and age groups. TIMSS looks at the link between the curriculum and student achievement, PISA looks at preparation to become constructive lifelong learners, and the ROSE project explores student attitudes (see Jenkins and Pell, 2006). As a result of the concentration on different aspects of student interest and performance, these international studies draw different and often conflicting conclusions. However, they contribute to the overall picture of attitudes, and enable comparisons to be drawn between national systems.

It was the emerging, and disappointing, picture of school student attitudes to science that prompted a profound re-examination of the purpose and ambitions of the science curriculum below university level. The decline in attitudes towards science began in later primary years (Murphy and Beggs, 2003) and continued to decline in secondary schools. This decline worsened over time; in 1995 some 80% of ten year old students said that they enjoyed science lessons, but by 2003 this had fallen to 68%, despite rising levels of performance (Ruddock *et al*, 2004). This decline was probably less to do with the National Curriculum (introduced in 1988) and more to do with the pressure of school league tables, alongside greater emphasis on literacy and numeracy. These issues in primary schools raised the pressure on primary science, while often making less time available to carry it out. The decision to phase out the written examinations for science at Key Stage 2 (age 11) from 2010 and Key Stage 3 (age 14) in 2009 signalled to schools that science was less important than previously indicated.

Prior to the introduction of the National Curriculum in England and Wales in 1988, there had been a general acceptance of the status quo at secondary level, given that each school had been able to interpret flexibly the needs of its intake and provide courses to meet the interests of staff and students. Only the ‘O’ level and GCSE syllabuses provided any commonality. With the National Curriculum, the stage was set for deeper reflection of national and local needs, and for a reappraisal of the purpose underpinning science education.

The debate began almost immediately with a questioning of the need to provide ‘science for all’, with the aim of improving broad public understanding. Millar (1996) summarised the arguments by identifying the key purposes of science education for different parts of society, and he made clear recommendations for the content and structure of the curriculum. Although this was a concise and tightly worded paper in a national rather than international journal, Millar set the scene for much later discussion. Indeed, the conclusions stated by Millar in 1996 were recognisable in the new GCSE frameworks introduced exactly a decade later. In recognising the role of empirical data and also the inductive and speculative aspects of science in schools, this polemic accepted the need to move away from the transmission of factual scientific information which typified teaching in the period before the National

Curriculum. The paper challenged the positivism of the typical traditional teaching style, and gave permission for the introduction of debate, dispute and uncertainty. Millar himself wrote in a style accessible to teachers, and in so doing initiated much discussion of underlying philosophy and enabled teachers to consider and question the existing models.

While the contribution of Millar was to consider the issues and possibilities, other authors have conducted research to explore attitudes and responses. An example of exploration of student opinion was carried out by Osborne and Collins (2001). This study used a series of focus groups during the 1998-1999 academic year, using 20 groups to cover male versus female and scientific versus non-scientific groupings. In all, 144 students were involved, from the three cities of London, Leeds and Birmingham. The study employed coding to identify emerging issues and a ‘grounded theory’ approach (Strauss and Corbin, 1994). While this approach allowed a deep analysis of the views of these students, the study had significant difficulties in extension of the interpretation beyond the groups being studied. The number of students contributing to the study, while a good size for such a research method, was very small in relation to the overall number of 16-year-old students in the country. Furthermore, the selection of students from three large cities is problematic as their experiences, views and backgrounds are unlikely to be representative of the national picture. The authors investigated the views of students in ‘normal state education’ and by implication they did not consider the views of students in private education, the views of whom are often found to be more positive towards science. Indeed, the method employed and the selection of students for the study seem both likely to encourage more negative views that would be representative of the population as a whole. Even the authors recognise the difficulty of the focus-group method:

> Given that most pupils were simply astonished to be asked to express their views, there was inevitably a tendency to express long-harboured dissatisfactions.
>
> (Osborne and Collins, 2001, p.444)

Despite these accepted limitations, the findings agreed with those found in a number of similar studies. For example, Delpech (2003: p.156-7) noted with concern that:

> Many students lose any feelings of enthusiasm that they once had for science…..they develop a negative image of science which may last for life.

The findings of the ROSE studies in numerous countries have arrived at a similar, and surprising, result. The attitudes of students were closely correlated to the status of the nation as a ‘developed’ or ‘less developed’ economy (see Jenkins and Pell, 2006), and not to the nature of the science curriculum. The more general factors affecting student views can be linked to teaching methods, assessment, and degree of difficulty of the subject, but the underlying question is:

> …why students seem to take a rather discouraging view of the contribution that science and technology are able to make to the alleviation of poverty…
>
> (Jenkins, 2006: p.66)

Crucially, the contribution of the international studies, and foremost the ROSE project, has been to illustrate that the deep-seated opinions of students were based on the wider perceptions of the national society, and not entirely based on what happens in the classroom. This immediately throws into question the validity of numerous studies and discourses that have explored the impact of localised changes in pedagogy and curriculum content. For example, Scott (2006) identified key research texts relating student responses to authoritative ‘telling’ and dialogic ‘discussing’ by the teacher in science lessons. Many other studies (see Beyond 2000 - the NSTA position statement, 2003) have similarly sought to identify factors that influence student enjoyment, engagement and progress in science lessons. Studies have repeatedly shown small impacts from increased student participation and greater relevance of the content to everyday issues. However, these studies do not shape society, and do not alter the foundations of student attitudes.

Indeed, the response by the Government has been to address the problem of student attitudes and the supply of science graduates by introducing more of the strategies that failed to improve matters in the past. The Science and Innovation Investment Framework 2004-2014 (HM Treasury, 2006) signalled a return to Triple Science (separate GCSEs in Biology, Physics and Chemistry) for the more able students – those attaining Level 6 or above at Key Stage 3. This entitlement, starting in 2008, and linked to an additional requirement for all Science Specialist Schools to offer Triple Science, could be seen as a return to the traditional approach to science teaching that was typical in Britain in the 1960's. This move was in addition to the guidance which accompanied the introduction of the new GCSE specifications in 2006 (QCA 2005) directing schools to ensure that Double Science (as opposed to a single GCSE) became the norm for the majority of students. In other words, the pressure was towards doing more science at GCSE level, rather than considering the reasons why students currently chose against continuing with science into A Level (post-16 study).

In addition to concerns about student attitudes to science, the DfES had long recognised that the supply of suitably qualified science teachers had become an increasingly intractable issue. Although the problem was marginally less acute in 2006 than previously, the continuing difficulty of recruitment (ParliamentToday 2006) would be a barrier to the expansion of science provision as planned by the DfES. A detailed NFER survey of science teacher provision (Moor *et al*, 2006) confirmed widespread perceptions about the state of the workforce. Some 8% of currently employed science teachers were non-specialists, and more than a quarter of 11-16 (Key Stage 3 & 4) schools did not have any physics specialist on the staff. This did not sit well with the move towards Triple Science and the need to teach Physics as a separate subject. The survey also identified issues in the qualifications of teachers at A Level (age 16-18). Only 50-60% of teaching was being carried out by teachers with a degree in the particular science, and 10% of teaching was carried out by teachers with no post-A Level qualifications in the subject. The survey would seem to be reliable, being based on a 40% return from the selected sample of a quarter of all schools, and thus involving 2756 responses. The detailed analysis also confirmed that the shortages are currently worse in the East, South East and London areas, where the cost of living was higher and the profession was consequently less attractive. The age profile of the teaching profession in Britain included a further timebomb in the supply of qualified science teachers. In 2004, 32% of male teachers and 29% of female teachers were in the age range 50-59, with retirement frequently at age 60 (source: TeacherNet.gov.uk). Only around 1% of teachers were aged 60+, and by implication the vast majority of teachers aged 50+ would soon leave the profession. A very large proportion of physics and chemistry specialists fall within this age category, and thus the profession would be destined to lose these teachers over the period 2004-2014.

It was further significant that the NFER study failed to consider three factors of great importance. The overall staffing position at a given instant may appear adequate, but this could disguise (a) staff mobility / turnover, (b) periods of unfilled vacancies, and (c) posts filled with temporary and/or overseas trained staff. These factors are highly significant for students, and although a school may report an essentially satisfactory workforce, the experience of students may be less encouraging. Consequently the survey, commissioned by the DfES, tended to under-report on the difficulties experienced at school level.

The survey did hint at inequity in the distribution of staffing. The problems were more acute in schools with no Sixth Form, and in the lower-performing schools. The greater availability of biology graduates led to their over-representation in the most challenging school contexts.

(b) Student choices

The changing patterns of student choices at the end of Key Stage 3 (Year 9, age 14) prompted the DfES to commission a literature review by NFER (McCrone *et al*, 2005). This review reflected a number of changes in statutory arrangements affecting the selection by students and the provision of courses by schools. Of significance here was the possibility of disapplication for science, meaning that in certain situations a student could be removed from the requirement to study at least one science GCSE course. The study by McCrone *et al* actually offers little to the current study for two reasons. First, the possibility for disapplication was removed from 2006, and all students are required to study a science. This had the potential to arrest the decline in Double Award science (see McCrone *et al*, 2005, p.17) and the new dynamic has yet to be identified. The second issue with the NFER study was that the outcomes appeared to offer little to the debate. The Key Findings in this report stated merely that 'None of the identified studies focused in detail on the complex interplay between the different elements of the decision-making process…..' (p.1) and suggested that for students the factors in making a subject choice were enjoyment, career usefulness, and ability in the subject. The extrinsic factors (parents, careers education, and teachers) were identified, but with comments that the research was divided and the balance of factors was 'not entirely clear'. The comment that 'Young people appeared not to opt to study a subject unless it held intrinsic or extrinsic value to them' was hardly a revelation.

While this study by McCrone *et al* offered little new, it did identify the paucity of research and the need for more detailed work. The review drew heavily on the methodology of Lord and Harland (2000) in their work for NFER, commissioned by QCA, to investigate the appropriateness of the National Curriculum. The continued work by Lord (2002; 2003) and Lord and Johnson (2004) to explore the literature and the changes in the National Curriculum has done much to highlight ongoing issues. For example: 'Science remains the most frequently researched subject area from the pupils' perspective, followed by maths, English, PE and PSHE '(Lord and Johnson, 2004: p.2) was useful context, since the continued decline in popularity seen by Harland *et al* (2003) was placed within a broader field of corroborating research, and was linked to perceptions of difficulty of Double Award science. The difficulty of science in comparison with other school subjects is increasingly documented (Fitz-Gibbon, 1999; Coe *et al*, 2008), and has greatly affected student attitudes. This subject differential, with the consequent effects on motivation and willingness to take science study beyond the statutory minimum, has rarely been taken into account in studies on attitudes to science.

One issue identified by McCrone (ibid.) was the influence of teacher input and teaching style in affecting the choices made by students. The implications of this were further explored by Smithers and Robinson (2005) in their analysis of the continuing decline of Physics in secondary schools. This study, supported by the more general look at science teacher supply by Moor *et al* (2006), confirmed the widely held view that Physics is in a cycle of decline, with fewer and fewer specialist teachers qualified in the subject, and an ongoing fall in the numbers of students choosing the subject at A level. The implications for the DfES were worrying and remain so. The introduction of Science For All in the 1980's ensured a general level of scientific knowledge throughout the population, but had seen a continuation of the decline at A level and university. Instead of raising the popularity of science as a career or study option, the replacement of the separate sciences (Biology, Physics, Chemistry) with Double Award had the opposite effect. Fewer students made choices aged 16 from a position of having studied any particular science in sufficient depth. As a result, the falling numbers studying science at university, along with high demand from industry, saw a consequential dramatic fall in the supply of science specialists to teach in schools. Smithers and Robinson (ibid.), looking at Physics in particular, found that nearly a quarter of 11-16 schools (without the attraction of teaching at A level) had no physics graduate teaching science. Even taking the wider view of all teaching at 14-18, only 38% of physics teachers had the subject as their main qualification.

The methodology employed by Smithers and Robinson (ibid.) consisted of a 10 per cent sample, scaled up to estimate the general national picture. This level of sampling was likely to be an accurate reflection of the overall pattern, and was thus more representative than some of the reviews mentioned previously. In addition to the intended outcomes, this study also confirmed views held anecdotally within the teaching profession. For example, many young science teachers are female biologists, and many male physics teachers are over 60 years old, and often continuing to teach on part-time contracts. These facts have serious consequences. Within an aging teacher workforce, with a very large proportion of teachers close to retirement, the loss of male role models and physics specialists will be disproportionately high. Smithers and Robinson suggested that the output of physics teachers from training institutions needed to rise from 450 to 750 per year. The DfES (now DCSF) remians well aware that this continues to be a pious hope in the light of continuing decline of A level and degree-level physics, and hence the dwindling supply of potential science teachers.

A large number of issues related to teaching style have influenced student choices and whether they choose to continue science courses into A level and beyond. Ever since the policy statement by Her Majesty's Inspectors 'Science 5-16' (DES 1985) and the subsequent introduction of the National Curriculum in England, students should have followed a science course throughout their primary schooling. The SAT National Tests should have ensured consistent teaching of content. In reality, the students continued to enter secondary schools with an extremely varied prior experience, and often claimed to remember little of their primary science. The pedagogy of primary science varied according to the experience and confidence of the teacher (see Nott and Wellington, 1999), and the priorities of the school. In addition, the teaching at all levels and at all ages is increasingly influenced by the perceived demands of the examination system, rather than the needs of students or society. Consequently, too many science lessons become little more than instruction on how to pass the next set of examinations. Despite this experience, students entered secondary school with an expectation of exciting science, which was too often dashed by three factors:

- Teachers at all levels were increasingly reluctant to engage in practical work where a degree of assumed risk could be present. Frequently, these 'urban myths' about banned experiments were unfounded or were misinterpretations of guidance (Surely that's Banned?, RCS, 2005). With less experience, less confidence, and less academic background, many teachers avoided exciting novel practical ideas and relied on the simpler textbook examples.

- Because of the varied teaching in Key Stage 2, secondary schools frequently found that they could not assume that students had knowledge from the primary phase (Nott and Wellington, 1999), and consequently the secondary teachers revisited basic topics (Harlen *et al*, 1995). This caused stagnation and boredom during Key Stage 3 (Galton, 2002), and produced increasingly negative attitudes toward the subject.

- Schools often used their weakest and least experienced teachers with the youngest students. This was a pragmatic – but often flawed – policy to use the best practitioners with the examination classes at GCSE and A level. Arguably this built problems that the school has to deal with later, but the practice has been widespread. Little research has been done on the subject, but it is a practice familiar to every secondary teacher.

These factors, impacting as they did on the attitudes of students, were generally understood, but had been researched to different degrees. In addition to the literature review commissioned by the DfES (McCrone *et al*, 2005), the DfES also commissioned NFER to carry out primary research into the decision-making process faced by students aged 14-16. This research (Blenkinsop *et al*, 2006) identified the key factors in choices made at the end of Key Stage 3 and at the end of Key Stage 4. Their findings, based on interviews with 165 young people, placed great emphasis on the extrinsic factors, namely the school guidance and support mechanisms. Much less was made of the intrinsic factors such as enjoyment and success in the subject, and this emphasis does not accord with the review of existing literature, also carried out by some of the same team from NFER. The findings in Blenkinsop *et al* (2006) did not always paint a coherent picture. For example:

> Schools can make a difference to how young people make decisions. The research shows a link between schools which appeared to be effective in relation to …..student support……and young people who were making the most rational, thought-through decisions……(p.ii)

and

> When students felt supported in decision-making by the school they were more influenced by school factors (such as individual talks with teachers and careers education and guidance provision)…..(p.ii)

both indicate the role of the school careers guidance and support in helping students make the right choice. However, these findings do not agree with a later statement:

> Few young people, particularly at age 14, made the link between careers education and guidance activities and the actual personal decisions they were making, suggesting the need for schools to make such links more explicit. (p.iii)

Therefore, this paper appeared to disagree in its identification of extrinsic factors as being more significant than intrinsic, and thus placing emphasis on structural rather than individual influences. It also appeared to be unclear as to whether the support and guidance provided by the school was indeed being heeded by the students in their choices. Despite these inconsistencies, the paper did highlight a trend that has been discussed at conferences for several years – namely the status of vocational courses.

(c) Work-related Learning

Two factors had in the past driven the DfES to place high emphasis on the provision of vocational or work-related courses in schools. The first had been the flurry of concerns voiced by the CBI to suggest that school-leavers were poorly equipped for the world of work (CBI 2009, p.7), and actually had poor functional skills despite the rising levels of attainment at GCSE and A level. These concerns were regularly voiced every summer, as soon as the examination results were announced. There is little research basis for these views, but the political power of the statements was sufficient for them to carry weight. Emotive comments on the levels of literacy and numeracy prompted the DfES to introduce awards of ‘Functional Skills’ in English, mathematics and IT, for phased delivery from 2008. However, the pressure had also driven the DfES to introduce a plethora of initiatives to increase the uptake of vocational courses at GCSE and A level. These were strongly supported by industry (Science Education Forum, 2006) but adoption in schools has been patchy. The reasons for this, as discussed in Blenkinsop *et al* (2006), stem from the low status of these vocational courses in terms of future entry to A level and to university courses. The vocational courses were held in low esteem by parents and students alike. This resulted in such courses being provided to a restricted number of students.

The second factor driving the DfES to encourage vocational courses was the increasing disaffection of a small core of students, progressively disenchanted and disengaged from the mainstream of school teaching. By providing practical and applied learning of skills linked to particular careers or vocations, it was hoped to keep the disaffected students in school and not dropping out to form an educational under-class of NEETs (Not in Education, Employment or Training). This aspect is subject to reform as part of the '14-19 debate', but reawakened the spectre of Secondary Modern schools catering for less academic students by providing a restricted education pathway and work-related education. For this reason, students, parents and schools have not found this a popular route.

The less extreme alternative was to adapt GCSE courses to reduce the purely academic content and replace traditional content with relevant applied and contextualised learning. Science was the first subject to be reformed in this way, in 2006 (QCA, 2005). The government funded resources to all schools to enliven science teaching and make it relevant to everyday contexts. Examples have been Bill Bryson's A Short History of Nearly Everything, and Al Gore's An Inconvenient Truth, both provided in CD / DVD format.

(d) Uptake of science post-16

While the government arrested the decline of science uptake at age 14 by removing the possibility of disapplication and stressing the DfES commitment towards Double Award as a minimum entitlement (QCA, 2005), there has been little progress at A Level, where science uptake continues to decline (Smithers and Robinson, 2005. See also Guardian Unlimited, December 2003). With freedom of choice at A Level, 16 year old students were able to make choices based on personal preference and were influenced by the same intrinsic and extrinsic factors identified by Blenkinsop *et al* (2006), and McCrone *et al* (2005) for Key Stage 3. The decline in uptake prompted the 'SET for Success' Review (Roberts, 2002) which identified a number of key issues:

- A shortage of women choosing to study these subjects at A Level and in higher education;
- Poor experiences of science and engineering education among students generally, coupled with a negative image of, and inadequate information about, careers arising from the study of science and engineering;
- Insufficiently attractive career opportunities in research for highly qualified scientists and engineers, particularly in the context of increasingly strong demand from other sectors for their skills; and
- Science and engineering graduates' and postgraduates' education does not lead them to develop the transferable skills and knowledge required by R&D employers.

These factors, identified by Roberts, were only in part amenable to solutions at school level. To a large extent they could only be tackled within university and in the workplace. Supply and demand, linked to changing expectations, may bring about changes. However, these issues cannot be entirely divorced from the issues at school level, which are in reality more open to government intervention. These factors at school level include:

- Shortages in the supply of physical science and mathematics teachers
- Styles and methods of teaching
- Poor teaching environments for practical science and DT
- The ability of courses to inspire and interest students, particularly girls
- Subject-related extra-curricular activities
- Careers advice which may affect students' desire to study STEM subjects
- Ways that the views of parents, teachers and society may portray science

The Roberts' Review was a critical piece of work, in that the issues and solutions were laid out in stark terms. For example:

> The Review therefore recommends that the Government and Local Education Authorities prioritise school science and D&T laboratories, and ensure that investment is made available to bring all such laboratories up to a good or excellent standard, as measured by Ofsted. (Roberts, 2002, p.191)

However, despite such detailed and authoritative research and collation of data, many significant issues remained to be addressed by the Government. For example, the Government has reneged on its investment in labs (Guardian Unlimited, March 2006). The demand for school leavers to be skilled in STEM subjects is central to the CBI requirements for the workforce (CBI,2009) and yet very little progress had been made to address this need in the previous decade, i.e. the period of the National Strategy for Science.

2.6 Conclusions

The issues of changing student attitudes towards science, changing social aspirations, and changing demands from the workplace and research have all been the subject of study. The literature reflected growing concern and interest in these topics, and a number of attempts have been made to provide reviews of extant papers (eg. McCrone *et al*, 2005; Osborne *et al*, 2003) as well as provide polemic position statements (eg. Chapman,1991; Black, 1993). The literature available since 2000 expanded in both scope and breadth, and included a range of styles from personal reviews (eg. Delpech, 2003, Scott, 2006) to detailed international studies (eg. Jenkins and Pell, 2006, Schreiner, 2004).

It was significant that the level of concern within the British Government, reflecting the changed circumstances and the need to compete with other knowledge-based economies, resulted in a growing range of investigations commissioned and sponsored by the DfES (eg. Blenkinsop et al, 2006) as well as major reports leading to policy decisions (eg. Roberts, 2002; DfES Five year Strategy, 2004; HM Treasury Science and Innovation Investment Framework 2004-2014).

The urgent need to address the supply of scientists and STEM specialists for the economy was undoubtedly the prime driving force behind the thinking of the DfES, just as the actions to increase the study of Modern Foreign Languages was driven by a need for international competitiveness. This emphasis on the economic rather than the academic purposes of education can be seen in the Roberts Report 'SET for Success' (2002) and the subsequent publications from the DfES and Treasury (eg. Investing in Innovation, 2002). It would therefore seem apparent that the fundamental motivation had moved away from what is 'right for the individual' in the strict sense, and towards 'what is right for the nation'.

The unresolved question is whether the moves in schools to create a generally scientifically literate population can create a workforce with the skills and aspirations to fill the demand for workers and researchers in areas of science. There is a need for investigation, at school and student level, to establish whether the current courses, in the current society, have had a sufficiently positive effect to reverse years of declining interest in school science.

The science courses cannot be divorced from the social matrix in which they are taught. Many external influences affect student perceptions, and with the range of media and peer pressures, the changes in school science may not have predictable results. Furthermore, the demographic changes, leading to a shrinking workforce and a raised demand for workers, will enable future cohorts of school-leavers to be highly selective in their choice of higher education and career pathways. Many less-desirable career options will find increasing difficulty in recruiting staff.

In this context, research into the effectiveness of DfES policies and guidance in changing student attitudes to science will continue to be of great importance. This is the driving force that prompted the research in this paper.

CHAPTER 3 Methodology

In this chapter the research approach is discussed, and each component process is described in order to explain how valid was the gathering of results and the analysis of the information. The decision to use a case study methodology is explained, as is the decision to use a range of sources of information to generate coherent and valid outcomes.

The methodology was chosen with due consideration of ethical issues and the pre-existing relationship between the researcher and the school. The context of the chosen school, and its characteristics, are described, in order to justify the selection of this institution.

3.1 Philosophical position

Within the study of school operations, the philosophical approach in research in this field is hotly contested. Tuckman (1990) felt that too much educational research had serious deficiencies, and indeed Devitt (1991) stated that "Constructivism attacks the immune system that protects us from silliness." Goldstein (1998), Hargeaves (1996), Woodhead (1998) and others argued for a pragmatic, positivist approach and Matthews (2002) was highly critical of constructivism in areas of science education. However, there are many other authors who claim that this positivism is not valid. For example, Bhaskar (1979) and Howe & Eisenhart (1990) claim that positivism is no longer a viable epistemological doctrine for this type of study. Punch accepts that "Educational research is contested and heterogeneous…." and that "The issue of perspective, perhaps more than any other, applies unevenly across different social science areas……and especially in some applied research contexts, it is not seen as relevant at all." (in Denzin and Lincoln, 2000, pp.83-97)

Within this arena, I employed qualitative methods, specifically where appropriate an essentially inductive qualitative approach, interpreting observations and constructing meaning in line with the methods advocated in Miles and Huberman (1994) for the coding and reduction of data. This stance, giving an essentially utilitarian outcome, accepts the position of Punch (2000, p.36) that: "On the contrary, research may proceed from the more 'pragmatic' approach of questions that need answers, or problems that need solutions."

The use of mixed paradigms (qualitative and quantitative), although accepted by Punch (2000), was discussed in Creswell (1994) and not considered ideal. Where one approach is dominant, the epistemological differences are acceptable (see Smith, 1983); indeed, the methodological eclecticism may have benefits in countering the limitations of each approach. I chose to employ qualitative methods of analysis, interpreting the data, whether the source was interview, observation, or questionnaire. Indeed, the questionnaire structure included Likert scales and free-response sections, and little that could be considered quantitative. Gorard *et al* (2004) identified that current qualitative research in education is commonly flawed, but has been more frequently used because it is seen as being easier. Since my own data were essentially qualitative, particular care was applied to counter this criticism.

Coming from a background in Natural Sciences, the issue of research philosophy has not previously been a great issue for me, and previous work has adopted a positivist approach based on empirical evidence. This is not unusual as '…many social researchers get on with their work without concern for philosophical problems, just like their peers in the natural sciences.' (Shipman, 1997, p.31). This naivety may have reflected an overestimation of the extent to which natural sciences are truly quantitative, and an assumption that 'science' can be a unique and privileged venture which could deliver an ultimate knowledge of reality. However, "Unlike the natural sciences, the social sciences have not, for the most part, been able to dissociate themselves from philosophy."(Hughes and Sharrock, 1997, p.1) Indeed, "…the aim of much of social research is, in effect, to show what difference the adoption of a particular philosophical point of view, especially in epistemological matters, makes" (ibid. p.5). The natural and pragmatic response in much of current educational research is to tend towards positivism as a basis, unconsciously adopting the apparent certainty of a scientific approach without recognising the inherent flaws in this approach in the context of social sciences. Some writers (eg. Hughes and Sharrock, 1997) are highly critical of positivism, although they do recognise its place:

> It is easy to be confused about, and misrepresent, the nature of the reaction against positivism. In particular, it is too easy to misunderstand it as a denial of all utility to those research techniques of social research allegedly sponsored by positivism, such as the social survey, questionnaires, and techniques of statistical analysis. (p.15)

In fact, much of the criticism of the positivist position has been the emphasis on explanation rather than understanding, with some writers seeing these as opposites and seeing more mileage in the hermeneutic nature of understanding in social sciences. With these reservations, I chose to adopt an interpretivist approach although, as Hughes and Sharrock (1997, p.25) conceded: "The growth of such fields as educational research……as endeavours within higher education institutions, and associated with the human sciences – have revived positivism's fortunes in some ways." There have been many reactions against positivism since 1960, though these various reactions have often been misunderstood as a denial of all utility of research techniques based on positivism – such as surveys, questionnaires and statistical analysis.

I describe the approach in this research to be a form of interpretivism (Miles and Huberman 1994, p.8), because I could appreciate that my own understandings of transactional dialogue, as a member of the particular culture in a school, were a factor in the interpretation. Rather than enter the research with a particular and precise hypothesis to explore, I was open to emerging issues and was prepared to ground conclusions in the evidence. While accepting a presumption of a general truth to be discovered from a range of evidence, I accepted that the conclusions would be contextual and embedded in a personal understanding of the activities in a school. In other words, my extensive prior experience was a factor in the analysis and understanding of data and processes.

Since the research explored student responses (responses to questionnaires and interviews, and responses to teachers in lessons), it necessarily begged the question whether the students were products of their society or whether they created their personal society. In other words, to what extent were they influenced by society around them, and to what extent were they influencing society with their views. I took the stance, based on long professional experience, that students have always been highly influenced by media, peers, family and social surroundings. To a far smaller extent do the students, through their views, influence their teaching and the wider beliefs held by the broader society. This point is critical, since the opinions held by students could be taken to reflect the general influences upon young people, rather than individual and possibly idiosyncratic beliefs of separate students. Although the students will in turn grow into influential adults who will impact on the opinions held by future students, at the time they are at school the influence is very one-sided (see Shipman, 1972). Young people are under the sway of society at large, and have little impact upon it themselves. These issues have been discussed by Adam Smith (1776), and by Durkheim, who recognised the collective individuality, and the potential to explore it through empirical methodologies. Indeed, "Durkheim…spelled out how social facts could be treated as things. Hence, social research could use the methods of natural science." (Shipman, 1997 p.25,). This does permit the use of interpretivism to explore the responses of the students in some situations.

Ontologically, the research is based on phenomena that are broadly observable (including responses to questions about attitudes), and the research process translates concepts into empirical indicators based on what is observable, recordable or measurable in some objective way (Lazarsfeld and Rosenberg, 1955). This is done with a clear understanding of the dangers of 'the lure of 'hard' data' (Shipman, 1997, p.26), but equally an understanding of the purpose of this research, namely to gain an insight into the impact of the National Strategy on student attitudes. It is necessary to adopt an approach that will conform to the methods used in current educational research in order to generate a 'hard' analysis. Whatever its attractions, an interpretive or inductive approach with 'soft' data would be less persuasive with the educational establishment.

The choice of a case study, using multiple sources and types of data, was taken after careful consideration of alternative approaches. The primary concern was an ethical one, in that the research could not risk disrupting the work of the school to the detriment of the students, and any intrusive research methods could risk the 'Hawthorne Effect' whereby the outcomes were affected by the process.

In addition, the time available on-site was limited by professional considerations, and thus approaches such as Action Research were discounted, as were linear and extended ethnographic studies. The case study approach, as described in Bassey (1999), permitted both exploratory and descriptive operations, within a context.

> Unlike research based on samples, it keeps attention on contexts, never extracting variables from the conditions in which they arise. It is therefore very suitable for aiding professional practice. (Shipman, 1997, p.61)

3.2 Research approach

My involvement as an adviser in schools, and in particular the one chosen for the case study, could open the door to unintentional bias: "There can be no naïve observation of facts, no pure empiricism. There are always preconceptions." (Shipman, 1997, p.29) With my own immersion in this field, I could recognise the risk of my own bias, and that of my colleagues who may contribute opinions at all stages of this research. It is inevitable that professional work in the implementation of the Science National Strategy would formulate views on the success of various components, and this could influence conclusions. Given this caveat, the choice was deliberately taken to use interpretivist qualitative methods to explore different dimensions of the issues, and to build upon the strengths of this approach. Some authors see this approach as part of a wider picture (see Henwood and Pidgeon, 1994), and I chose to use an interpretivist approach to give both depth and breadth to the research, allowing my wider experience to understand, but not prejudice, the analysis of the data.

I also decided to employ multiple sources of evidence, in order to explore different aspects of the issue and provide a form of triangulation. This approach of using information from different data sources to corroborate the same facts and phenomena was described in Yin (1994), citing the approach of Patton (1987). The validity of case studies using this approach has been rated highly in terms of quality (Yin, Bateman and Moore, 1987). It was also felt that offering a 'real' example of actual practice – rather than of research away from the embedded context – would negate some of the frustrations felt by teachers when confronted by research findings that appeared to lack 'translatability' into their own school context:

> Too much of teacher education is unbearably generic, offering vague and general principles that purport to apply broadly to a vast range of situations.
> (Shulman, 1996:p.198)

The advantage of this approach, while accepting the point that there may be no single truth or fact in a study of this sort, would be to bring out different perceptions seen by participants in the study. This approach allowed an exploration of the issues from differing standpoints, and consideration of why any contrasting views are held. The approach adopted is similar to that described by the COSMOS Corporation, cited in Yin (1994):

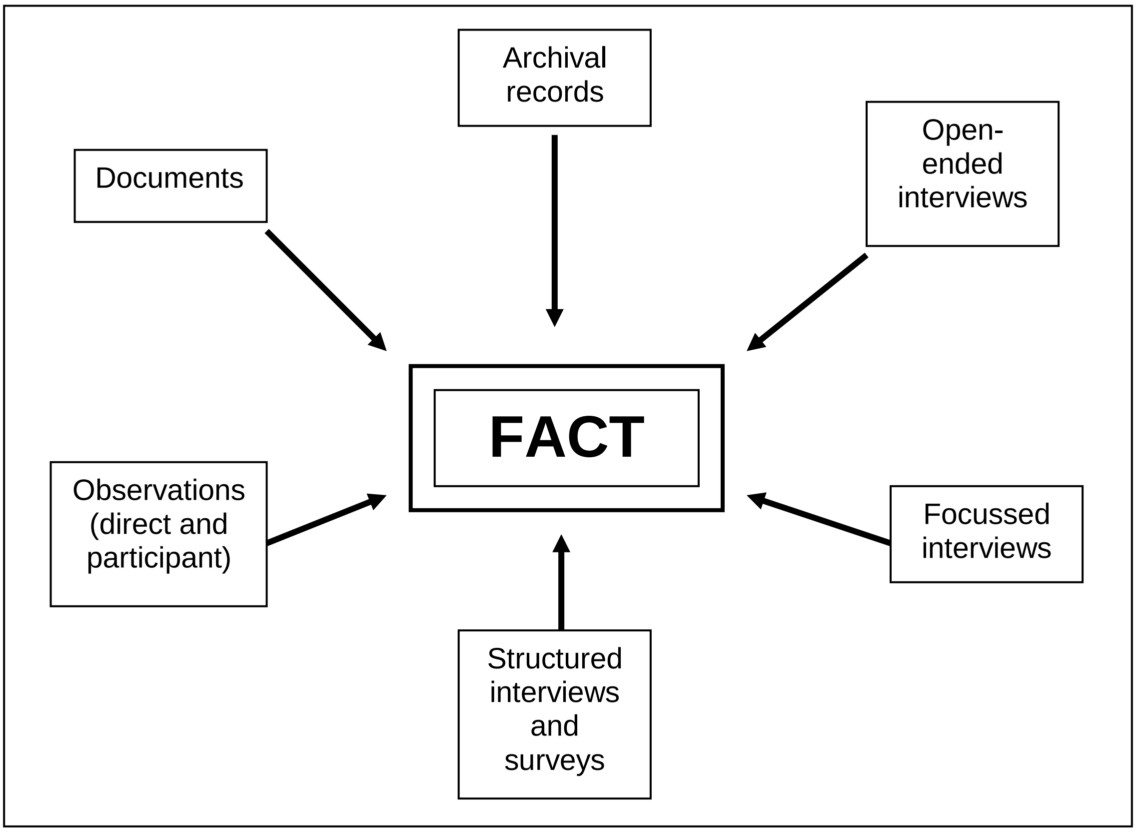

Figure 2: Convergence of Multiple Sources of Evidence (single study)

Two phase approach

Fundamental to the use of different sources of data, the research was conducted in two distinct phases, with four years separation between. In 2004, a wide ranging survey was conducted, using a questionnaire format, to gather data from a number of schools. The purpose of this initial phase was to explore variability between schools, and to establish an understanding of the National Strategy as the training period reached its conclusion. By chance, the Phase 1 research included Ashbourne School, later selected for the case study in Phase 2 of the research. The Phase 1 study established that the questionnaire content did not present problems for students, and also confirmed the appropriateness of sample sizes and analysis methods.

Following the Phase 1 investigation in 2004, the second phase of the research was conducted in 2008, with a detailed case study of one school, where changes over time could be explored and where student attitudes could be examined. The two phases of the research were thus critical in providing a comprehensive investigation into the changing response to the National Strategy approaches and the effectiveness of the Strategy in driving systemic change in schools.

3.3 Case Study Methodology

The use of Case-based Reasoning (CBR) explores the extent to which the interpretation of a case study can be applied to other examples. Freebody (2003: p.81) described this focus on one particular instance as a way to gain theoretical and professional insights, based on lived dimensions with a strong sense of time and place (see Bassey 1999). The value of a Case

Study is thus to use an inquiry to reflect on the particular instance, and avoid theorising in a vacuum.

The chosen approach was a descriptive model, moving into an exploratory study, seeking to answer specific questions within the context of a typical school. The case meets the four central attributes outlined by Shulman (1996, p.207-8), and also answers the need for validation through multiple accounts of the phenomenon. Thus the choice of a Case Study approach was valid in this situation, and could be effectively employed to answer the research questions.

The fundamental questions with this methodology were: ‘what is this a case of?’ and ‘how applicable is this to other cases?’. In the chosen study, the proposal was to research the role of the National Strategy in a school, thus reflecting on the impact of the Strategy since its introduction through to a time when the initiative should have a discernable impact. As for applicability in other schools, this hinged on whether the case study school was typical of other institutions, and whether this would mean that the outcomes could necessarily be expected elsewhere. Would two similar schools be expected to produce the same outcomes? While this may not be true in all situations, it was hoped that the study demonstrated results that were at least recognisable in other schools, or reflected elements of similarity. Even though ‘small qualitative studies are not generalizable in the traditional sense’ (Myers, 2000) it is possible for users of the findings in one case study to find patterns that are similar in their own personal case (see Stake, 1995). This naturalistic generalisation may be ‘fuzzy’ (Bassey, 1999), but can offer a valuable insight for the reader.

3.4 Details of the Case Study

The aim of the study was to carry out a descriptive case study in a single institution, and to be as rigorous and detailed as the method will allow. The traditional prejudices against case studies – that they are sloppy, contain bias and have little basis for generalisation – were discussed by Yin (1994), but the same criticisms could be applied as easily to experiments and surveys. The justification for choosing a case study method in this situation was that the phenomenon could be investigated in a natural context. This method could help to explain causal links between observations. Shulman (1996: 207-8) described the attributes of a case study in education, and at the planning stage, this research met the criteria, particularly in terms of judgement and reflection.

The study involved seven discrete methods of data collection, providing triangulation and a test of internal validity. Freebody (2003, p.82) described case studies as empirically ‘omnivorous’, and listed the typical sources of data. My chosen research included:

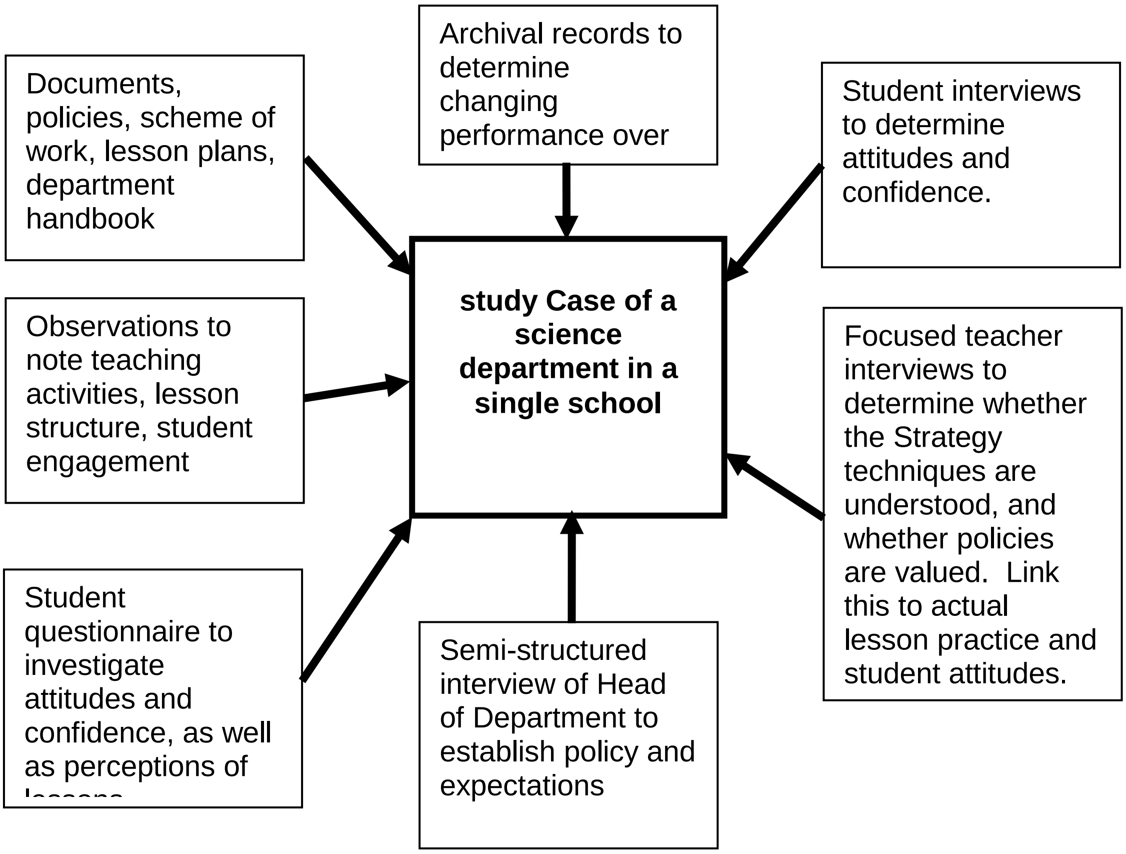

Figure 3: Evidence used in the Case Study. Adapted from : Convergence of Multiple Sources of Evidence (single study) in Yin (1994)

Some social science research is concerned with interventions, and assessing their outcomes, i.e. where the intervention exists because a problem needs a solution (Brink and Wood, 1994). Similarly, Tornquist, in Punch (2000) describes Intervention and Action requiring Evaluation and Assessment. This is certainly the model described in Punch where research questions are framed to answer general research questions by moving down the inductive-deductive hierarchy towards more specific research questions. This case study was thus conceived to assess the intervention of the National Strategy, and to assess its outcomes in terms of teaching styles and student attitudes. The specific research questions were designed to focus on recognisable outcomes.

The case study was primarily descriptive and idiographic at the outset, gathering and summarising data. In the future, this could move into an explanatory phase as further research follows, but with little existing literature on the topic, the initial phase must perforce describe the situation in a particular school context.

3.5 Research Context: Ashbourne School

The school chosen for the case study research was a non-selective upper school in Buckinghamshire, a fully selective local authority in England. On balance, the schools in the area perform well, but this is not uniform across the range of schools, and is not uniform within the age ranges of a given school. Selective Grammar schools are clearly able to select students of high academic ability, but some Grammar schools have a very high reputation within the community, and are able to select from the very top of the ability spectrum. Conversely, some non-selective Upper schools have a very low reputation, and attract only those students for whom places are not available elsewhere. School intakes are thus extremely polarised in ability terms, and alongside this is invariably polarisation in socio-economic, motivational and behavioural aspects. The selective system, therefore, represents a diversity of school types that is more extreme than would typically be found in areas of comprehensive schooling.

This diversity was not considered by the DfES when planning and promoting the National Strategy and delivering the training in schools. As Harris (2000: p.9) explains: 'It is only recently that the field has recognised the need to take into account contextual factors and independent variables in selecting and applying school improvement strategies.' This issue is also discussed by Hopkins, Harris and Jackson (1997).

Working in this sector, it has been possible to identify factors that appear to operate in these school types. Thus, the chosen school was identified because it displayed characteristics that would enable the research to be productive:

- Receptive to local authority involvement
- Generally typical of non-selective schools in the area
- Effective leadership at all levels
- Stable staffing over the research period
- Keen to be involved in research to benefit students
- Geographically convenient
- Involved in the 2004 Phase 1 questionnaires and interviews

While to some extent, the choice of school was dictated by all of these factors, the most significant was that this example represented a typical 'middle-of-the-road' school in the area, with no particular factors making it atypical in any respect. Thus, for the purposes of the research, Ashbourne School was ideal in that it may indicate where findings could apply more widely to other similar schools.

Ashbourne School is a Specialist Sports College in a medium-sized market town in central England. The school has a curriculum that is typical of most schools, and the specialism does not have a significant bearing on the style of teaching. The examination results in the past have been below average, and the school was subject to Special Measures a number of years ago. The school has recently been supported by the National Challenge programme, and the GCSE results have improved.

Ashbourne School is located in an area of housing in the outskirts of the town, with a large school site and relatively well-kept buildings. The surrounding area has pockets of social deprivation, but the housing estates are uncrowded and have areas of open green spaces. There is little in the clean and tidy surroundings to suggest the degree of relative deprivation in the households. Most of the students come from the nearby housing, but a significant number come from further afield in more affluent areas. The majority of the students have positive attitudes towards their education, despite having failed to secure a place at a selective school, and behaviour around the school is good. Only a minority of students create difficulties, and most students want to succeed at school.

The school is well-managed by an enterprising headteacher, and a strong sense of purpose can be seen within the leadership team. The science department is relatively stable, with the turnover of staff being no more than average. The profile of the teaching staff ranges from older and experienced staff through to trainee and newly-qualified teachers. The teachers and the support staff are enthusiastic and work well together, so that the atmosphere around the school is positive and welcoming.

Statistical data describing Ashbourne School are included in Appendix 1. As a non-selective school in an area with full selection, the ability profile of the students is skewed towards the lower end, with a marked loss of the higher ability range. However, the Contextual Value

Added for the school in 2008 was exactly 1000.0, making the school exactly median on the 50th percentile rank for all schools. Thus, in terms of the progress made by students, the school is by definition ‘average’. In many other characteristics, the school is broadly typical of a broad swathe of other schools, and would only differ significantly from those schools in strikingly challenging or advantaged situations. Data for the school in 2008 (the date of the main study) are presented in the appendix. The school has been broadly stable, and data for 2002 (introduction of the National Strategy) and 2004 (date of Phase One study) do not differ significantly from the 2008 figures.

Students in Ashbourne School often have clear views about what and how they would prefer to learn. Their maturity of understanding about the process of learning is unexpected, and they speak confidently of improvements that they would like to see. The school is proud to offer the students ‘an environment where they feel happy, safe and secure.’ (prospectus 2009, p.1). The school collaborates with other schools and FE colleges in the area, to provide a range of courses suitable for all students. The school considers that it offers a ‘dynamic curriculum’.

3.6 Methods of data collection

3.6.1 Interviews

Semi-structured interviews were conducted with individual teachers and with groups of six students. The protocols for the interviews were discussed with the school management in advance, and followed the procedures used in school inspections in the local authority. The school informally monitored the process in order to avoid any problems.

In the case of the teachers, the interviews were conducted in private rooms, enabling the teachers to give their views in conditions where any criticisms of the school or misgivings about the National Strategy could be conveyed in a strictly-followed process where the discussion was both confidential and anonymous. The interviews were recorded on video (in order to capture non-verbal communication) and were transcribed in full. Interviews ‘…depend for their use on ‘theoretical’ claims about how the interview encounter can be managed in order to maximise the validity of the respondent’s answers.’ (Hughes and Sharrock, 1997, p.12). In other words, by careful choice of semi-structured or open questions, a conducive atmosphere and a good relationship, it was possible to create an environment where answers were valid – in that the responses reflected the views of the interviewee without influence from the interviewer.

The interviews were conducted in sequence with no attempt to analyse the discussions until after completion of the process, in order to avoid any bias from prior knowledge, leading to questions being influenced by preceding discussions. This was a deliberate decision, producing a sequence of interviews that could be compared, rather than an ongoing succession of increasingly exploratory stages. This also allowed the discussions to follow the thinking of the interviewee, rather than be dictated by the need to follow up on previous issues, and there was a need to exert some control on the process:

> A disadvantage of delaying the making of analytic decisions until after interviews have been conducted is that it may mean that different interviews take different paths… (Gomm, 2004, p.194).

The three student interviews (Y7, Y9 and Y11) were conducted in suitable rooms with six students seated in a row. With due regard for safeguarding and child protection policies, the students were informed of the confidentiality of the process, and were reassured that the video of the interview would be erased after transcription. Furthermore, the students were allocated cards with letters (A-F), and their names were not recorded. The nature of the discussions gave confidence that the students felt able to speak freely.

The use of group interview techniques for the students is not without issues. Clearly, it is possible for the students to have been influenced by the comments of others, and to either echo their views or at least be triggered into respond along similar lines. Equally, a student may not feel able to be open and honest in front of their peers, and may not express views that are ‘uncool’ in student parlance, in that the views run against the group opinion of their peers. These reservations about the use of group interviews were set aside for several reasons. First, experience shows that students speak freely in these contexts, and openly discuss views at variance with the majority. Far from agreeing with the others in the group, students appear ready to contradict the others, and this can be seen from the transcripts. One-to-one interviews are often quite stressful for individual students, and they may not speak out when alone and unsupported. Second, individual interviews would have been too time-consuming for the researcher and too intrusive into the lessons of the students. By taking all six students from one science lesson, the disruption and inconvenience to the school was minimised. Third, in terms of the school’s Child Protection Policy, it would not have been appropriate to be in a private room with a single student for an extended period.

On balance, therefore, it was judged that small group interviews were the most suitable vehicle for the collection of data.

As with the teacher interviews, the student interviews were transcribed in full, capturing any non-verbal communication, simultaneous comments, and fragmented sentences.

Analysis of the interview transcripts followed the process described in Cohen and Manion (1989, pp. 329-333), whereby the full transcripts were read in full – and also watched on the video – to gain a sense of the whole meaning, and general themes were identified (Silverman, 2000, p.149). The transcripts were then explored in detail, identifying specific themes and sub-themes by coding references and meaning within the text, clustering these within broad areas of relevance to the study. In some instances, new and unexpected themes emerged from this process, and re-categorisation was an iterative process until the structure of themes appeared to reliably capture the issues raised by the interviewees.

To further confirm the thematic reduction and grouping of ideas, the interviews were cross-checked to explore whether a point raised in one interview had been present in others, but had been missed. Similarly, each interview transcript was again matched against the grouped themes to confirm that both the detail and the overall meaning in each interview corresponded to the identified themes (see Strauss and Corbin, 1998).

Every possible step was taken to avoid contamination of the analysis by preconceptions, derived from personal involvement in the field. Two independent reviewers, one an educationalist, one not, were asked to read the transcripts and match these against the identified themes, in order to confirm the interpretations made in the analysis.

The themes as identified in this analysis provided the structure for section 4.2 of this research.

The option of using a computer program to analyse the transcripts was discounted after consideration because the low number of separate interviews (3 student, 4 teacher, 2 other) did not merit this approach. Furthermore, it was felt that the physical grouping of themes was more adaptable and easier to visualise than a computerised model.

3.6.2 Questionnaires – purpose and methodology

Social surveys have attracted much criticism as a positivist vehicle, largely because of the status accorded to this method and the rigorous analysis of the data so collected (Hughes and Sharrock, 1997). Despite the issue of mixing qualitative and pseudo-quantitative approaches (see section 3.1 above), the questionnaire survey was an essential part of this case study. The purpose was three-fold.

First, it provided a broad (as opposed to deep) look at the issues and enabled the study to cover and reflect the views of a large number of students. This was helpful in developing a ‘fuzzy generalisation’ (Bassey 1999: p.11) and permitted a meaningful comparison with previous years, with other schools, and between year-groups within the school.

Second, it provided a degree of check to determine whether the views of students expressed in the context of interviews were significantly different from the views expressed by their peers. This could be seen as checking the validity of the interviews, but could also generate questions about why any variation occurred.

Finally, the questionnaires identified particular issues that could be explored in more detail during interviews with students and with teachers. In many cases, the planned interview questions were modified to explore issues raised in the data from the questionnaires.

3.6.3 Questionnaires - scope

The questionnaire survey conducted in 2008 covered 50+ students in each of Years 7, 9 and 11 in the case study school. The purpose of this choice of year groups was justified as follows:

- **Year 7** (age 11-12) had newly arrived into secondary education, from a range of primary feeder schools. As such, they could freshly remember their experience in their previous school without undue influence from their current secondary science experience.
- **Year 9** (age 13-14) were preparing for their end of Key Stage 3 SAT examinations. As such, they had experienced the full teaching programme for the Key Stage, and should have seen the benefit of the National Strategy teaching methods. As it transpired, these would be the last cohort of students to take these examinations, since the DCSF announced the cancellation of the written examinations in October 2008.
- **Year 11** (age 15-16) were in their last year of compulsory education, and preparing for their GCSE examinations. The attitudes of these students towards science, based on their experiences thus far, would determine whether they would choose to continue with science-based courses post-16. To a large extent, the attitudes of these students would be a measure of the success of the National Strategy for science.

In addition to the questionnaire survey conducted within the boundaries of the case study, further Phase One questionnaires – using identical methods – were conducted with Year 9 students in 2004. These surveys provided additional lines of evidence of any distinct changes between 2004 (soon after completion of the initial phase of National Strategy training) and 2008 (by which time the embedded impact of the National Strategy should be evident). In the analysis of the questionnaire surveys, the 2004 survey will be discussed where significant differences exist in the 2008 study.

As a further check, the 2004 Phase One studies included the chosen case study school and a range of five other schools with a similar context. This made it possible to identify whether the chosen school displayed any variant data which could indicate that the students were affected by unforeseen factors making the school atypical.

In the event, and somewhat against expectations, the schools in the 2004 phase showed very low variation. This indicated that the responses were characteristic of 14 year old students in the region, rather than being characteristic of particular schools and the experiences within them.

3.6.4 Questionnaires – approach

The full protocols for the questionnaire survey were carefully considered with the Headteacher and the Head of Science, to ensure that the process was agreed in detail and that the students would not face stress or disadvantage. In order to avoid bias and self-selection, the questionnaires were presented to students without prior notice. Permissions had been obtained from the Senior Leadership of the school, but the class teachers were not notified in advance, to avoid any coaching of answers.

The questionnaires were given to students in their tutor periods, and the completion was overseen by the class teacher. This ensured that the students were comfortable, that they did not miss any teaching time, and that all students completed the questionnaires carefully and in silence. A further advantage was that the students present came from a range of different science groups, rather than one science class. This ensured that a good coverage of different lesson experiences would be sampled, as well as reassuring the students that the survey would not serve to criticise an individual teacher. In each case, the purpose and confidentiality of the questionnaire was explained to the students, and any questions were answered. All of the sampling took place simultaneously.

A minimum of 50 questionnaires was sought for each age group, but the actual number administered was much greater because whole classes were involved, and the number of students depended on the class sizes. Supervision by the teachers ensured 100% completion rate, and in 18,000 individual question responses, only four item responses were clearly flippant or false. In fewer than ten item responses, the student misunderstood the question, or failed to answer. (See Appendix 5 for questionnaire)

3.6.5 Phase One questionnaires

The questionnaire had been used in six similar schools in 2004, in each case collecting data from around 60 students (depending on class sizes). The results were extremely consistent between schools and this allowed three significant conclusions:

- The attitudes of students were surprisingly consistent between schools
- There was little variation between sample groups within the same school
- The sample size of 50 was sufficiently large to give reliable results

The questionnaire sample schools in 2004 included the school selected for the full case study. This enabled comparisons to be drawn between 2004 and 2008 when the main study took place.

The Phase One questionnaire revealed few difficulties with the wording and layout of the questions, and only one question appeared to need clarification. In the main case study, administering teachers were given a written explanation to read to the students before the questionnaire was started. This appeared to resolve the issue, as demonstrated by the successful completion of the questions.

3.6.6 Lesson Observations

A range of lessons was observed using recording methods developed from Section 10 Ofsted inspections, with a primary focus on the use of National Strategy pedagogic techniques as well as the degree of interaction between teacher and class. The level of engagement of the students, as evidenced by their behaviour and the progress made in the lesson, was judged in consideration of the many factors in the lesson. Lesson observation is inevitably subjective, but established criteria were used where applicable.

The purpose of the lesson observation was to explore whether issues described during interviews or indicated in the questionnaire survey could be observed in practice. In particular, where data from one source conflicted with another, or required further exploration. By direct observation, it was also hoped to determine the extent to which lessons 'followed the rules' in terms of the format and processes in the school policy:

> Patterns of actions are explained by two groups of factors: dispositional factors such as attitudes, motives, feelings and personality; and sanctioned expectations (normative rules or role expectations) to which the individual is subject.
>
> (Hughes and Sharrock, 1997, p.105)

The lessons observed were selected from those available during the research period, and covered classes for the three study groups (Y7, Y9, Y11). The teachers were in agreement with the process, but did not know in advance which particular lessons would be seen. The teachers were asked to 'teach normally', rather than lay on a special event, and the evidence from student exercise books supported the view that the lessons observed were typical of the weekly routine.

Each lesson was observed from start to finish, and after the lesson brief feedback was given to the teacher in line with Local Authority protocols.

3.7 Data analysis methods

The aim of the data analysis was to examine the forms of evidence in order to draw meaning and clarity from the different data sources, and from this to capture the essential nature of the case study. In each of the diverse data types, the analysis was undertaken as described in each of the following sections, but in each case "The purpose of data analysis is to translate the evidence into a form which allows the researcher to make clear and concise statements of description and/or association" (Anderson and Burns, 1989, p.200). Thus the aim was to use the findings from this case study as an illustration of what is likely to be true in other schools sharing a similar context, and possibly to reflect the general position in a wide range of schools.

> The traditional empiricist principle is induction. It lets us infer that what has been found to be true in known cases so far also holds in other cases where the same conditions obtain. (Hollis, 1994)

The aim of the data analysis was therefore to present the results in a form that would be meaningful to teachers in other schools, and illustrative of the transferability of the findings to other contexts.

Chapter 4 Analysis of Results

In this chapter, each of the data collection methods is described in turn, and the results are described in detail. The outcomes are explained throughout the text and summarised in order to emphasis key emerging themes. The results from the four main sources (student questionnaire, student interview, teacher interview, lesson observation) are cross-correlated where significant issues arise.

It is significant that in the majority of cases, the results from the different sources were able to ‘tell their story’ in a coherent way, without internal contradictions, and without conflict with other sources, adding to the validity of the conclusions. The results from the initial phase of research in 2004 add great significance, as they illustrate changes from the peak of the National Strategy training to the point near the end of the Strategy.

In Table 3 (p.10) the research questions are linked to the data sources, and as shown in Figure 2 (p.37) the various data streams contribute to the final analysis.

The school’s own data illustrate the progress made in science (see Appendix 1) and illustrate how the school has moved to address low performance. However, the school has not documented the change in teaching approaches, and cannot therefore correlate the changes in student performance to changes in classroom practice.

4.1 Student Questionnaires

The process of administering and analysing the questionnaires is described in section 3.5. Great care was taken to ensure that the process was both confidential and ethical, and the student responses indicated both a full completion and a consistent response to all parts. Cross-checking between answers would indicate flippant or inaccurate responses, but this did not arise. The questionnaire responses were therefore highly reliable source of information. Phase one of the research, in 2004, used the same questionnaire with Y9 students, and the comparisons between year groups in 2008 could be enriched with comparisons with 2004 students.

The questionnaire data were not analysed by statistical methods because the essential nature of the data did not support this type of approach. The responses were too few for statistical validity, and the qualitative nature of much of the data – for example how much a student ‘enjoyed’ a subject – was too subjective to merit this style of interrogation. Several statistical approaches were considered to explore significance, and were trialled with results from the questionnaires. For example, in the Phase One data collection, the Chi-square method was used to determine the relationship between lessons beginning with a starter activity (73% of respondents) and good recall of prior work (71% of respondents). In this case the link was significant, with 95% confidence (and actually close to 99%), indicating a strong positive association, but it was felt that too many other factors could influence the apparent causal link between starter activities and good recall. For example, higher ability classes, with good recall of prior work, may be given starter activities, while less able classes could possibly move straight into the main activity in order to maximise the time on the task. Thus it could not be said that the starter promotes recall *per se*. After considering the possible tests for significance, the three factors (small numbers, qualitative responses, complex linkages) were felt to make statistical analysis unproductive.

As described above, the questionnaire data were both reliable and consistent, but this did not make the data amenable to analysis beyond basic percentages of responses. Thus, this decision was taken on practical grounds, rather than philosophical position (Strauss and Corbin, 1998, p.31).

4.1.1 Questionnaire analysis

The analysis of over fifty responses for each age category produced data with no issues of non-return or bias from the selection of registration groups which contain a randomised allocation of students (see section 3.5.4). The responses reflected the gender distribution within the school, with slightly more girls (between 4% and 12% more than boys, depending on group). The gender imbalance was not significant. The sample size ensured that the responses were representative of the whole year group, and the sampling process as described above ensured that bias was minimised.

In the following analysis, figures in parentheses represent the Phase One data from 2004, all other data are from the 2008 survey.

1. **Enjoyment of Primary Science**

The fundamental restructuring of primary science, with the introduction of the National Curriculum in 1988 and the widespread adoption of the non-statutory QCA scheme-of-work since approximately 2000, had raised the status of science to a Core Subject with assessments in Y2 and Y6. With the transition of science from 'the nature table' to a high profile central subject in the curriculum, it would have been hoped that the pupils leaving primary school would report a positive experience of practical and enjoyable investigative studies.

The five-point Likert scale was analysed for the number of positive and negative responses.

	Year 7	Year 9	Year 11
Enjoyed it a lot / Quite good	30%	34% (34%)	30%
Hated science / Didn't like it	32%	8% (31%)	30%

Table 4: Enjoyment of Primary Science: positive and negative responses

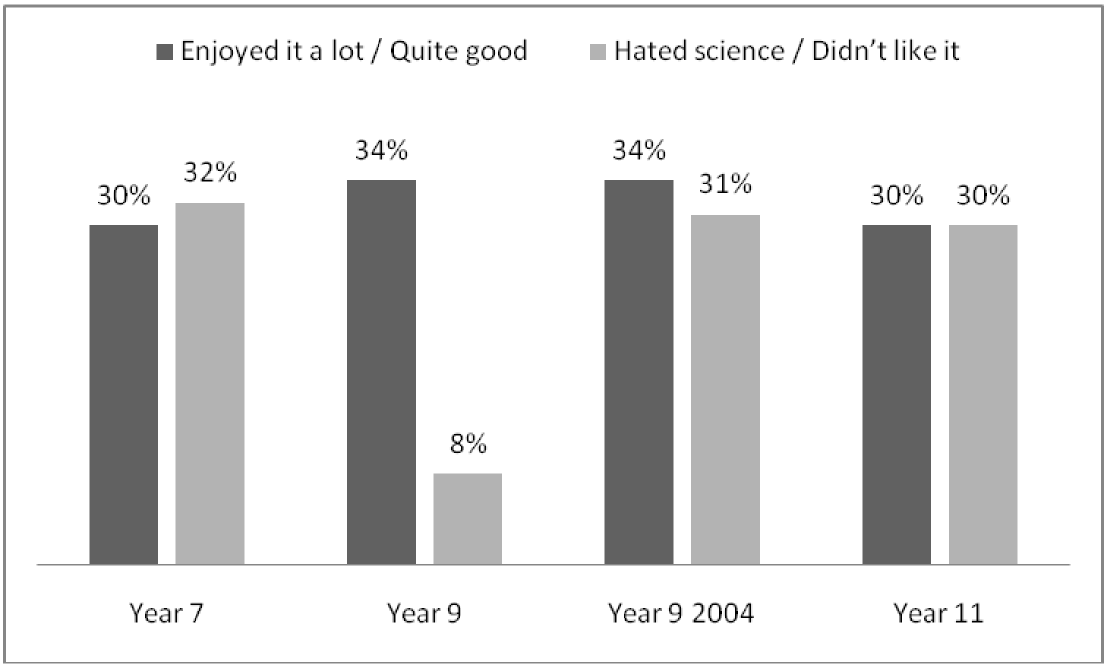

Figure 4: Responses expressed towards primary science

The responses were remarkably consistent, with the exception of the Y9 2008 group who recalled low levels of dissatisfaction with their experience in their primary schools. There is no obvious explanation for this striking difference.

The 2004 survey of Y9 (who left primary school in 2001) responded with more polarised views (17% enjoyed a lot, 22% hated science) than the current Y9 who responded with 4% in each extreme category. Given the strongly consistent data in other areas of the research, it is difficult to dismiss this difference between 2004 and 2008 as purely an anomaly. The 2008 cohort, having left primary school in 2005, had significantly fewer negative responses, possibly attributable to a local project in primary schools. However, the current research could not explore this further.

Overall, the responses demonstrated no clear shift in the perceptions of primary science over time, and instead a remarkable balance between those who liked and those who disliked science. More worrying, however, was that 22% of the Y7 – who had recent and relatively untainted memories of their primary school – recorded that they ‘hated’ science. There is no evidence that changes in primary schools have captured the scientific imagination of pupils.

The impact of testing in the final year of primary school, and the consequent emphasis on revisiting and revising work in a largely didactic manner, may contribute to the number of students who do not look back on their primary science with much enthusiasm (Collins, *et al*, 2009). Attitudes to science appear to be already becoming negative during Key Stage 2 (age 7-11) and the issues of testing and transition to secondary school may merely be contributory factors in an ongoing process.

2. **Enjoyment of secondary science**

The introduction of the Key Stage 3 National Strategy for Science aimed to improve outcomes and attitudes of students, primarily through improved teaching methods and greater awareness of how students learn science. A key criterion for success of the Strategy would therefore be improved enjoyment.

A Likert scale to explore views of science at secondary school used the same scaling as in the question about primary science. The responses showed a clear trend:

	Year 7	Year 9	Year 11
Enjoyed it a lot / Quite good	74%	68% (65%)	29%
Hated science / Didn’t like it	4%	8% (4%)	26%

Table 5: Enjoyment of Secondary Science: positive and negative responses

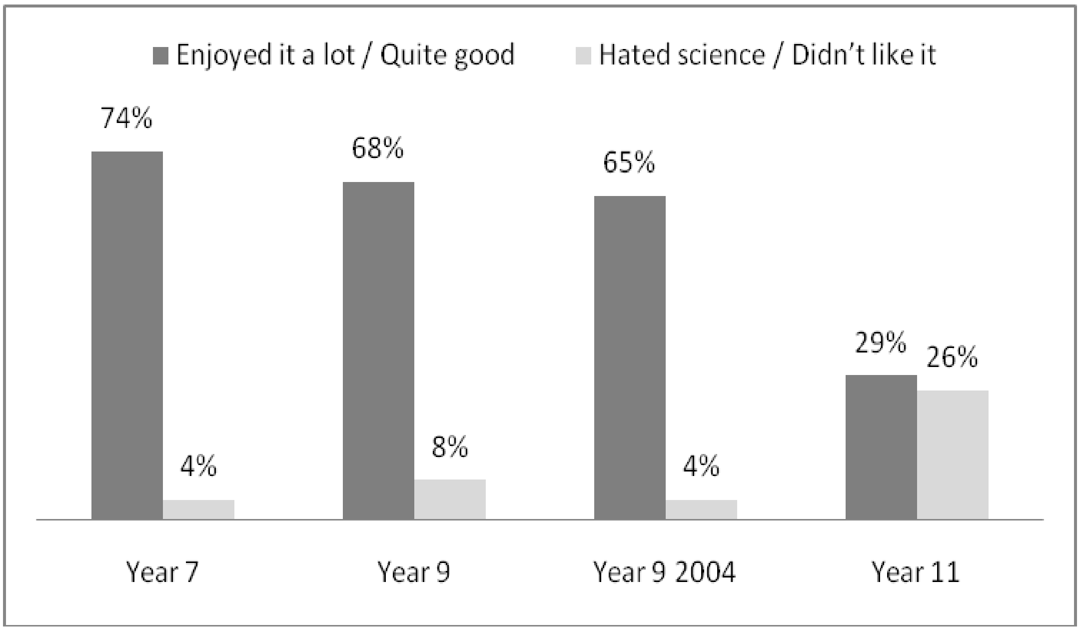

Figure 5: Responses expressed towards secondary science

The students in Key Stage 3 (Y7 and Y9) responded with a clear enjoyment of science, and the 2004 Y9 data were consistent with this. This was particularly striking in Y7, where no student 'hated' their science, and 30% 'enjoyed it a lot'.

However, by Y11 the students responded with less than half the level of positive responses, and far more negative responses. Evidently, the new GCSE courses, introduced in 2006, had not been successful in motivating the students since almost one in five responded that they hated the subject. It is supposed that there could be many reasons behind this perception, including the teaching methods, peer pressure and the relative difficulty of the subject. However, the various changes in science education in the last decade do not appear to have raised the levels of interest.

3. **Perception of capability in science**

The perception of capability is a key factor in the motivation of students. When a young person believes that they are doing less well than their peers, or less well than they are doing in other subjects, then motivation will decline. Continued study of the subject will become less likely.

This Likert scale asked the students to rate how good they felt they were at science. The results showed unambiguous trends:

	Year 7	Year 9	Year 11
Really good / Quite good	52%	36% (48%)	37%
Below average / Not very good at all	2%	14% (4%)	24%

Table 6: Perceptions of own capability in science: positive and negative responses

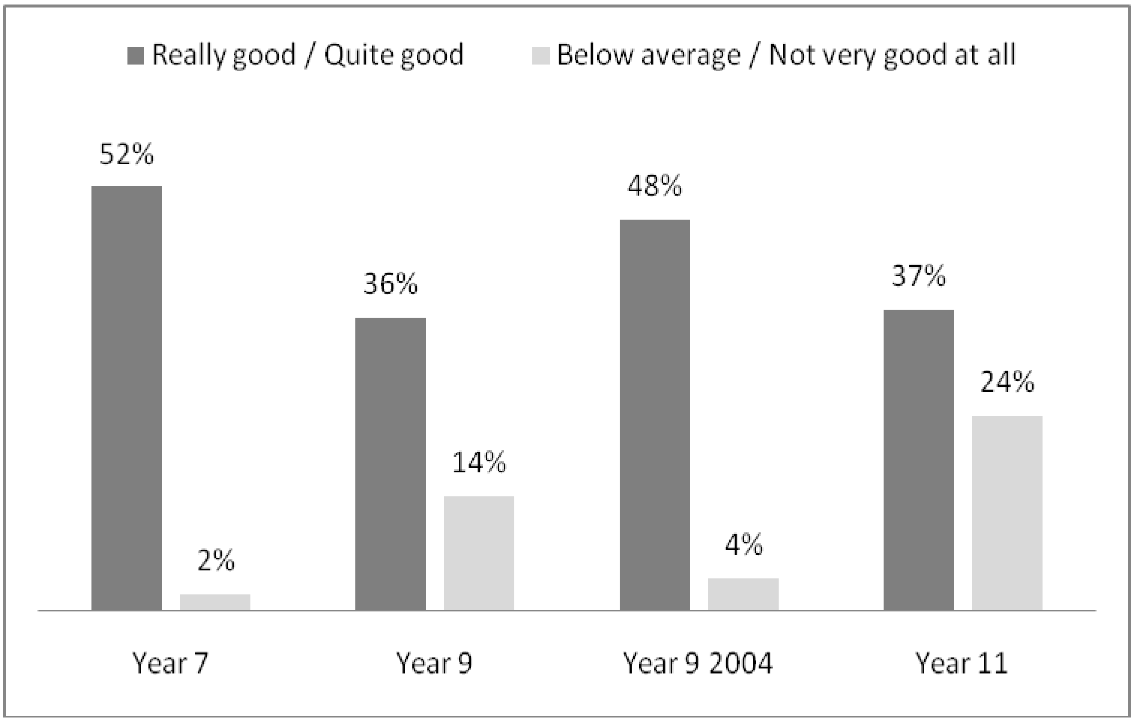

Figure 6: Perceptions of own capability in science: positive and negative responses

The number of students responding that they felt confident fell from a very positive picture in Y7, and the number of students with negative perceptions of their ability rose by a factor of 12 between Y7 and Y11. Indeed, no Y7 student responded with the most negative 'Not very good at all', while no Y11 student responded with the most positive 'Really good'.

The 2004 data suggests that the confidence of Y9 students has fallen over time.

Attributing a cause to these changes is problematic. The changes in the 2008 cohorts may reflect changes in teaching style in different age groups or changes in external factors. Equally, it may be that teaching had changed over time, such that the Y7 experience was different to the experience of the Y11 students when they were themselves in Y7. Similarly, the differences between the Y9 in 2004 and 2008 could reflect different teachers, different teaching styles, or the impact of the National Strategy. The case study approach does not provide enough evidence to explore this relationship.

4. **Popularity of subjects**

The relative popularity of school subjects will always be affected by a wide range of factors, ranging from the influence of individual teachers to the impact of image in society (see Blenkinsop *et al,* 2006). In this particular school, the views of students were remarkably consistent. The students were asked to rank by preference the ten subjects that they are taught in the school.

In all year groups sampled – and including the 2004 Phase One study – the most popular subject was PE, with technology and art ranked highly. These are all practical subjects with little writing involved. The least popular subjects were languages and geography. A general picture shows a broad inverse correlation between the popularity of a subject and the amount of written work done in the subject. Generally, the more practical work involved, the higher the subject was ranked.

Rank	Year 7	*Year 9* ***2004***	Year 9	Year 11
1	PE	*Art*	PE	PE
2	Art	*Music*	Technology	English
3	Technology	*PE*	Art	Art
4	**Science**	*English*	**Science**	Mathematics
5	Music	*Technology*	History	Technology
6	Mathematics	***Science***	Mathematics	**Science**
7	English	*Mathematics*	English	History
8	History	*History*	Music	Music
9	Geography	*Geography*	Geography	Geography
10	Languages	*Languages*	Languages	Languages

Table 7: Rank of 'favourite' school subjects, as identified by students

The relative position of science was very consistent: 4th in Y7, 4th in Y9 (6th in 2004) and 6th in Y11. Despite the declining attitudes and confidence in the subject, indicated by other questions, the relative position of science did not significantly change over time.

5. **Lesson structure: the Starter activity**

One of the main strands of the National Strategy was the introduction of the 'Three-part Lesson' which included a brief starter activity, the main lesson content, and a plenary to explore learning. With the assumption that every lesson would have some main activity, the identification of the recommended three-part lesson hinged on whether a starter activity and a plenary session was included.

When asked whether their lessons began with a starter activity, around half of Y7 (54%) and Y11 (43%) recorded that this was the case. In contrast, a much higher proportion (72%) of Y9 students recorded that lessons began with a specific starter activity. This figure had reduced since the early days of the Strategy, since the figure for Y9 was 83% in 2004.

The significance of these figures is reinforced by a corroborating question where students were asked how easily they could recall previous work and 'get into' the lesson. In Y7 and Y11, under half recorded that they found it easy (44% and 45% respectively) while a higher proportion of Y9 (68% in 2008 and 61% in 2004) replied in the same way. This provides a link between starter activities and the ease of thinking about the lesson subject. The similarity in the pattern of responses (similar levels in Y7 and Y11, and higher levels in Y9) has no clear explanation.

6. **Lesson structure: the Plenary session**

The concept of a plenary session at the end of the lesson (and possibly at other points within the lesson) was a key element of the National Science Strategy. This plenary was intended as an opportunity for students to think about their learning (metacognition) and reflect on the learning process. Students were asked about ways that their lessons might end, and multiple answers could be given by each respondent and thus overall response totals could be greater than 100%. The proportion of students recognising that they were given these opportunities was remarkably consistent over the sampled groups:

	Year 7	Year 9	Year 11
Do you have a chance to think about what you have learnt in the lesson?	40%	42% (43%)	36%

Table 8: Percentage of students responding that they have plenary activities

When asked in more detail about how the lesson ended, the results did not indicate successful embedding of the Strategy aims. The most common response was:

	Year 7	Year 9	Year 11
We just stop work, pack up and leave	56%	64% (52%)	82%

Table 9: Percentage of students responding that the most common end to a lesson lacked a plenary activity

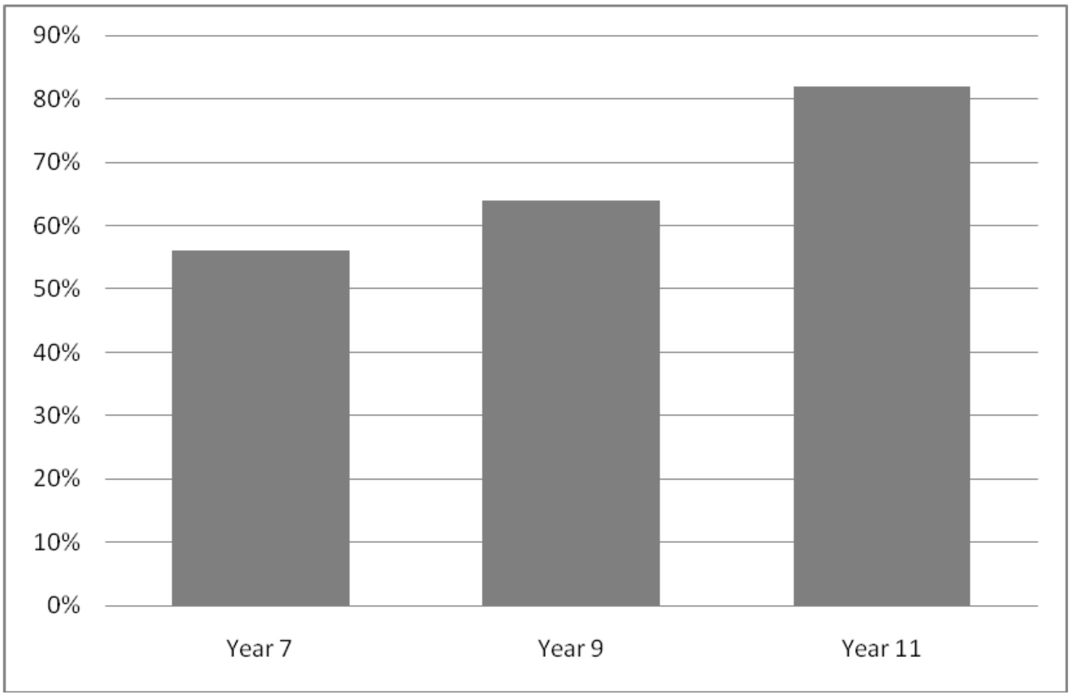

Figure 7: Frequency of students stating that the most common end to lessons was just to stop their work, pack up and leave.

This shows a trend where the older students have less organised endings to their lessons. This is reinforced by the second most likely lesson ending in each case, as follows:

Second most likely lesson ending was:	
Y7	Teacher sets homework (56%)
Y9 (and 2004)	Teacher talks about the lesson (44%, 57%)
Y11	Students chat until the bell goes (63%)

Table 10: The second most likely lesson ending (after 'Just pack up and leave')

The trend here was for decreasing formality and structure as the students progressed through the school, with an indication that in 2004, the Y9 students experienced a more organised ending than was true in 2008. Once again, the implication was that the Strategy aims were not embedded in classroom experience, while in 2004 the newly introduced philosophy for reflection on the lesson appeared more prevalent.

Thus, less than half of Y7 students, and dwindling to less than a fifth of Y11 students, felt that their lessons ended with a recognisable plenary session. They did understand the concept of the plenary as they encountered it in other subjects (as indicated in the interviews). The lack of a clear period of reflection at the end of their science lessons was therefore an indication that the three-part lesson was not a feature of many lessons. The reasons for this could include pressure of time in the lesson, lack of planning time to organise the plenary, or a failure to prioritise this component of the lesson.

The most likely ending (‘Stop work, pack up and leave’) might suggest time pressure within the lesson, but the second most common ending (‘Students chat until the bell goes’) clearly indicates a failure to build a plenary into the intended structure of the lesson.

7. **Frequency of Practical Work in Science**

Students were asked to identify the frequency of their practical work in science lessons. Their understanding of practical work has been shown to be different to that of the teachers (who included all non-book activities, including discussions, watching a video, and internet research). The students were generally clear in defining practical work as that part which distinguishes science (i.e. investigation) rather than activities that could as easily take place in other subject areas (eg. formal debates).

Given the difficulties of clearly defining practical work, the student responses were consistent and identified serious issues:

	Year 7	Year 9	Year 11
Every lesson / Most weeks	82%	34% (73%)	2%
Hardly ever / Never at all	4%	10% (0%)	52%
Not very often / Hardly ever / Never at all	10%	26% (22%)	89%

Table 11: Frequency of practical work

The first two rows in the table show the top two and bottom two responses from a six-point Likert scale, and demonstrate a considerable shift from frequent practical work in Y7 to infrequent in Y11. The final row in the table, combining responses from the three lower Likert-scale categories, is included for its stark message: In Y7 around 80% of students felt that they did practical work quite often, while in Y11 nearly 90% of students felt that they did practical work infrequently.

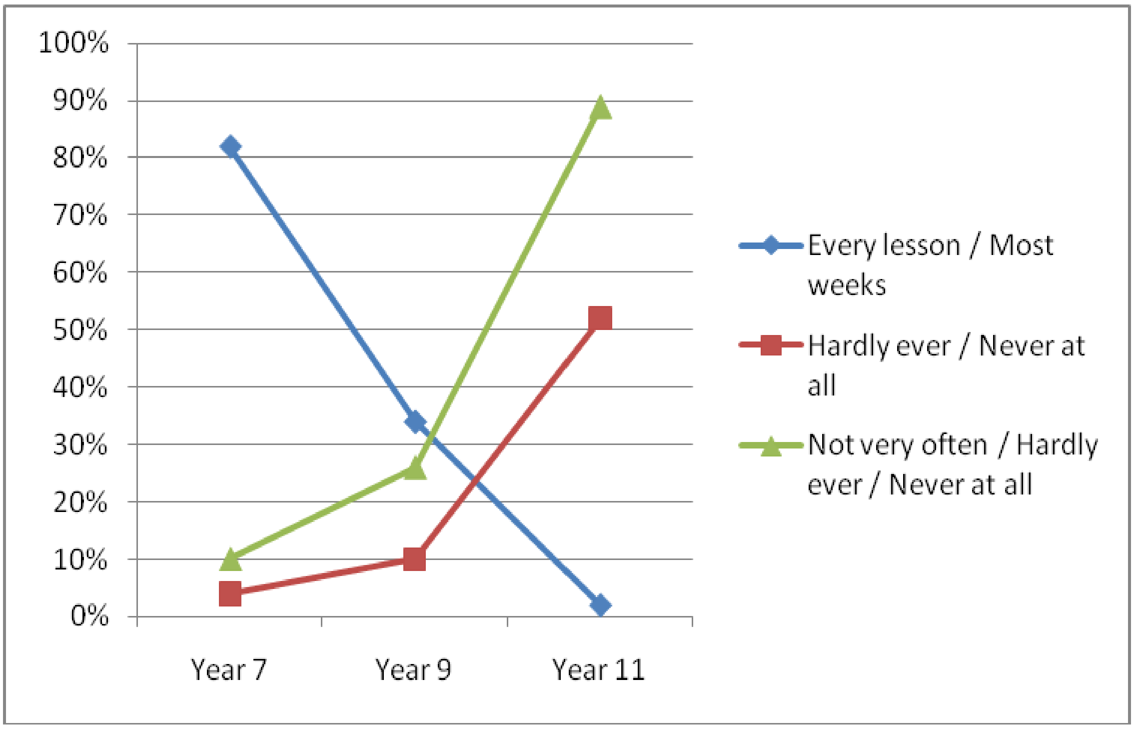

Figure 8: Changing frequency of practical work – student responses

Within Y9, the data from 2004 indicated a drop in the frequency of practical activities during the years until 2008. This was most sharply demonstrated in the response ‘Nearly Every Lesson’ which dropped from 43% in 2004 to 6% in 2008, while the number of students responding ’Most Weeks’ remained similar. The overall number reporting frequent opportunities for practical work fell from 73% to 34%, indicating a significant shift away from ‘hands-on’ learning.

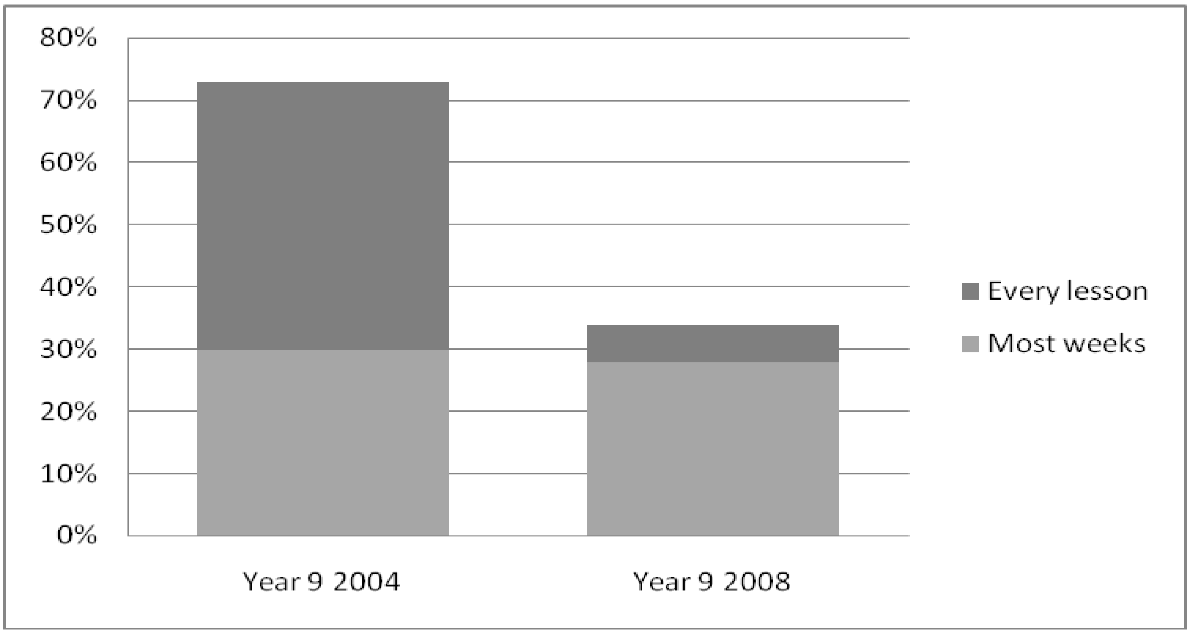

Figure 9: Frequency of practical work in Year 9, 2004 - 2008

The issue of the frequency of practical work thus showed two dimensions. First, there was a reduction as the student progressed through the school. This could reflect a shift from simple inexpensive activities that required basic equipment, through to more complex and expensive practicals where specialised equipment is needed. In this case, the school may have consciously or unconsciously reduced the number of activities offered to the older students. Another factor could have been the increasing emphasis on examination preparation, and the perception that the students need to spend more time learning facts rather than investigating for themselves.

The second dimension was the reduction in practical work between 2004 and 2008. This could have reflected factors such as reduced funding, changed priorities, teacher confidence, or syllabus changes, for example. Whatever the causes, there had been a clear shift away from the expectation of practical work in most weeks.

8. **The availability and use of ICT to support learning in science**

The expanding use of ICT to support learning has been inevitably associated with the expansion of computer technology and the internet in the wider society. However, the use made of this resource to assist teaching in schools has not progressed in schools as rapidly as it has developed in the home. Whereas the majority of young people in Britain have access to the internet at home, the frequency of school use is more variable. The questionnaire invited respondents to indicate in which locations they could use computers or the internet.

	Number of responses		
	Year 7	Year 9	Year 11
Computers in the lab	2	6 (0)	0
Computer and/or internet at school	32	20 (35)	28
Computer and/or internet at home	114	104 (118)	46
Data projector used in lessons	36	34 (9)	36

Table 12: Use of ICT equipment
(Number of responses given, rather than percentage, because answers are not all mutually exclusive.)

The responses highlighted a number of significant issues. The use of computers within the laboratory (for use as an integral part of the science lesson) remained minimal, and may indicate either the choice of the school to keep computers out of laboratories, or else a failure of teachers to integrate student use of ICT into lessons. The principal use of computers was by the teacher, with an extremely uniform recognition of data-projector use in teaching, with equal numbers of responses in all groups. The increased use of data projectors since 2004 is noteworthy, reflecting the greater availability of technology.

The use of computers – and invariably the internet – elsewhere in the school site is greater, but remains low. It demonstrated that the classes infrequently went to specialist facilities to use suites of computer equipment in this school. Cuban (2002) questioned whether the effectiveness of ICT as a teaching aid represented good value for the financial and time cost involved. There is little doubt that the students could readily identify the value of computers as a tool and as a research aid, but they were not yet experiencing ICT as a fully integrated part of their learning process. The teachers in this school still treated computer use as an 'add-on' rather than integral part of their lesson planning, yet this may reflect an informed choice about how best to use the technology, rather than a failure to make use of it at all.

In clear contrast, the students reported extensive use of computers at home, with the younger students making more use of the internet than the older students in the school. This may reflect a steady transition in the way that students interact with new technology, with the younger students having more access to the facilities or more confidence in its use. The extent to which computer use for school-related work was supporting science in particular is impossible to state accurately at the time of this research.
However, Wellington (2005) reviewed the spread of ICT use between 1982 and 2004, concluding that there had been little change in the pattern of computer use in schools and in wider society (p.34) with the majority of home use being for leisure interests, particularly for games playing. The pace of change may not have been evident to Wellington, and five years after this study, the dominant home use of computers has become social networking, with online purchasing now a growing activity. There is a growing expectation that students of all ages will use ICT at home for their studies, merging the use of computers at home and at school. Increasing use is made of e-learning and assessment / administration via the internet, so that Wellington's assertion:

> My guess is that in 50 years from now, many of the issues raised and questions posed in this article will certainly be alive and probably still kicking. (Wellington, 2005, p.37)

seems hard to justify, given the enormous developments in the last five years and the exponential rate of change. In 2005, it would have been difficult to predict that most students would soon have mobile phones with Wi-Fi internet connectivity, for example.

Despite this, the use of ICT as a teaching tool has continued to evolve slowly, and risks remaining backward in relation to the widespread and innovative use made of advanced technology in the home and in the workplace. Some experienced teachers still view ICT as an alien and unfamiliar component in the classroom.

9. **Confidence in Science examinations**

Many factors can affect the degree of confidence that students express when faced with examinations and tests. However, low confidence levels could reflect difficulties in learning and understanding the concepts, which would clearly be a factor in low attainment levels. The expressed confidence showed clear trends:

	Year 7	Year 9	Year 11
Really confident	10%	4% (0%)	0%
Feel fine	30%	20% (43%)	15%
A bit worried	12%	36% (17%)	37%
Really scared	4%	6% (9%)	16%

Table 13: Student confidence or concern before science examinations

The students were presented with a five-point Likert scale, and the extremes showed that none of the Y11 students felt 'really confident' and only 15% felt generally 'fine'. In contrast, the younger students felt more relaxed about their examinations despite never having taken external examinations at secondary school..

At the other end of the scale, the older Y11 students were more 'scared and/or worried' (see table 13) about the forthcoming examinations than were the younger students. This could be linked to a number of factors, and could reflect the greater importance of GCSE examinations in Y11 as compared to National Tests (SATs) in Y9 and school examinations in Y7. Given that the Y11 students were following a modular course, and had therefore already taken many of the examination papers that would contribute to their final GCSE, their low confidence could not be attributed to unfamiliarity with the process.

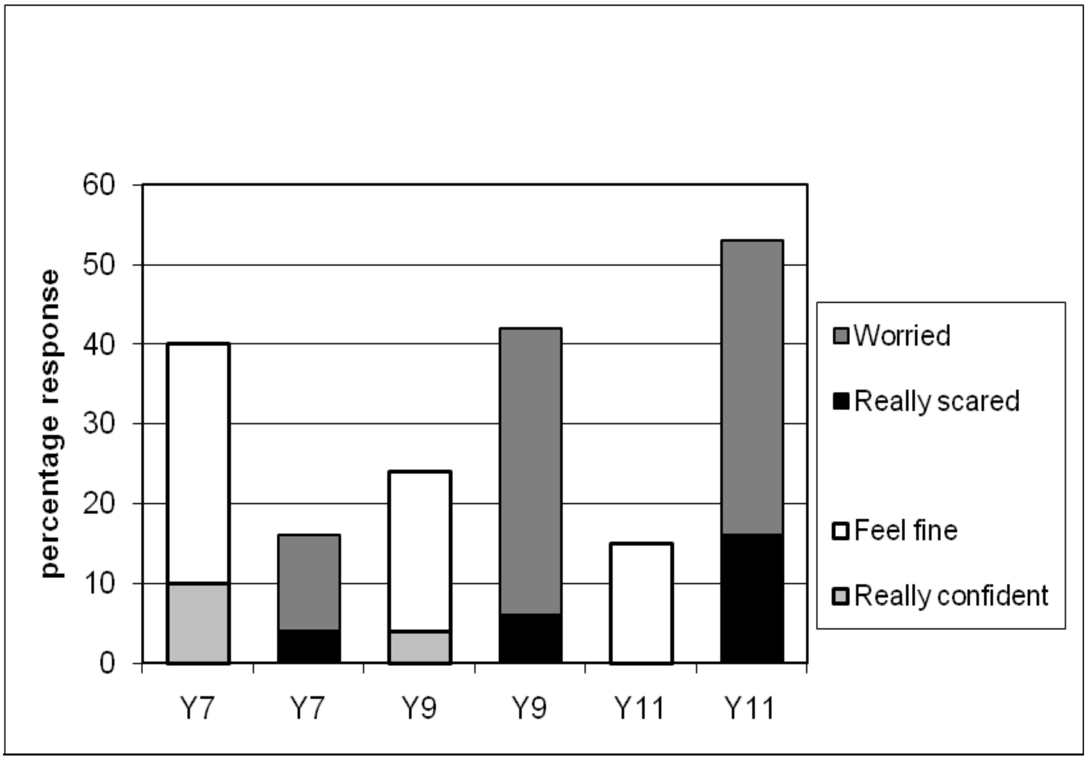

Figure 10: Student confidence levels before science examinations

In 2004, soon after the Strategy had been introduced into schools, the Y9 students were generally more confident and less worried than the 2008 cohort. This could be attributed to a more relaxed approach to examinations, or to differences in teaching style. Further research would be needed to explore this decline in confidence.

10. **Revision before examinations**

For many decades up until the introduction of the National Curriculum in 1988, the main source of revision notes in science had traditionally been the student's exercise book, relying on notes taken in lessons. The unification of programmes of study after 1988 allowed publishers to produce inexpensive revision guides for use by students (Oversby, 2005, ii). The pattern of revision resources used is generally uniform:

	Year 7	Year 9	Year 11
From published revision guides	20%	50% (78%)	75%
From own exercise book	56%	62% (70%)	62%
From revision work in class	54%	76% (43%)	57%
From revision exercises as homework	56%	44% (52%)	30%

Table 14: Percentage of students using different revision methods

There has long been a trend towards the use of commercially published revision material as students progress through the school, while the oldest students make less use of homework for revision. However, the pattern suggested that a wide range of revision resources were used by all students.

The decreased reliance on the exercise book as a primary source for revision is highly significant. First, the use of published revision guides removes any disadvantage experienced by students who lack essential writing or presentational skills. Second, the reduced need to record information during lessons, both practical and 'theory' lessons, should liberate time for other types of work, such as investigation or discussion. Third, the lack of emphasis on the exercise book may result in the teacher seeing this less often, and thus feedback or correction of work may not happen as regularly as in the past. Finally, the students may have less experience at recording scientific information in a structured form, and they may lack particular skills related to this process.

The trend where the use of exercise books in science is in transition from a dutiful record to a convenient jotter is visible in many schools. This has the potential to inject more interaction and variety into lessons, in line with one of the aims of the National Strategy for Science.

11. **Interaction with the teacher**

Another element in the National Strategy for Science was to improve interaction between the teacher and the individual student. This could take the form of directed questioning, differentiated work, and improved tracking of progress. The effectiveness of this was tested in the questionnaire survey. The students were presented with a Likert scale ranging from 1 (They know me well) to 6 (They have no idea) to record how well they felt known by the teacher. The results were generally positive, with particular strength in Y9 in both 2004 and 2008:

	Year 7	Year 9	Year 11
Response 1 or 2	36%	54% (57%)	29%
Response 5 or 6	6%	0% (0%)	15%

Table 15: How well students feel they are known by their teacher

The responses in Y11 were weakest, possibly as a result of the splitting of groups between two or more teachers for GCSE teaching, resulting in each teacher spending proportionately less time with the class.

Part of the interaction with the teacher was intended to include telling the students their target grades. When asked whether they knew their targets, this had clearly been communicated to the examination classes (Y9 and Y11) but less often to the Y7 groups:

	Year 7	Year 9	Year 11
Yes, I have been told my target grade.	46%	92% (52%)	91%

Table 16: Percentage of students aware of their target grade

A key element in the National Strategy for Science was the theme of higher expectations, and this included having greater awareness of progress, achievement, and how to overcome barriers and move to the next level. The process was later exemplified and developed in the Assessment for Learning (AfL) and Assessing Pupil Progress (APP) initiatives. The AfL process, dating from 2006, and based on the work of Black and Wiliam (1998) and Black and Harrison (2004), should have been embedded at the time of the research. Since less than half of the Y7 students were aware of their target grades, there is evidence that this initiative had not been fully implemented.

12. **Quality marking**

The National Strategy identified the quality of feedback as a critical factor in ensuring good progress in all subjects. Guidance was provided for teachers, and this has been further developed by initiatives such as Assessment for Learning (AfL) and the more recent Assessing Pupil Progress (APP). Despite this, the quality and frequency of marking and feedback are often identified as inadequate during school inspections by Local Authorities and by Ofsted:

> One problem is that marking to inform pupils of their progress is inconsistent, with teachers often giving insufficient guidance to pupils about how to improve their work and providing few opportunities for pupils to reflect on comments.
> (Ofsted, 2003)

The questionnaire survey confirmed this picture by the numbers of responses:

	Number of responses		
	Year 7	Year 9	Year 11
Book doesn't get marked	10	18 (9)	43
Book marked with a helpful comment	60	46 (74)	37
Book marked, NC level or GCSE grade	28	44 (39)	25
Book marked, numeric grade mark	26	32 (35)	25

Table 17: Feedback in exercise books
(Number of responses given, rather than percentage, because answers are not all mutually exclusive.)

It is a concern that so many Y11 students (more than half of responses) recorded that their science books were not marked at all. This could be explained in part by assessments being done separately, but may also indicate that the teachers concentrated on delivery of facts in lessons rather than checking what had been recorded. This raises the concern as to whether the apparent lack of written feedback had an effect on understanding, or on attitudes towards the subject.

13. **Progression in Key Stage 3**

One of the four component themes of the National Strategy for Science was ‘progression’, to counter the widely reported failure of students to make significant progress in their learning in Y7 (DfES, 2002). A contributory cause for this was repetition of primary school work in Key Stage 3 (eg. House of Lords, 2006, P.110(40); Estyn, 2004, p.20), with teachers failing to take account of prior learning. The boredom and disengagement exhibited by many students in Y7/Y8 has been put down to this lack of new and demanding work for the students (Morris and Pullen, 2007), and many schools are shortening the Key Stage to two years in consequence (DCSF 2004, 2006) . The impact of this has been varied, and at the time of writing this has not been researched in detail.

In the survey, students were invited to record their ‘feelings’ about science when they first started secondary school in Y7:

	Number of responses		
Most common replies:	Year 7	Year 9	Year 11
Boredom	24	14	16
Enjoyment	6	8	6
Interest	50	58	36

Table 18: Student feelings about science in Year 7
(Number of responses given, rather than percentage, because answers are not all mutually exclusive.)

The term ‘feelings’ was an expression that students would readily understand, but various options were given in the questionnaire as suggestions. The student responses used these and other similar words.

While students described being interested by their science, very few expressed enjoyment. This distinction was unexpected, but the apparent lack of enjoyment, as perceived by the students, was remarkably consistent throughout the age groups.

The students were asked whether they felt that the science work in Year 7 repeated topics already covered in Primary School:

How much work repeated during Y7?	Year 7	Year 9	Year 11
Most / Quite a lot	16%	24% (39%)	16%
Not much / None	40%	30% (18%)	48%

Table 19: repetition of work during Year 7

One significance in these responses is the demonstration that the issue of repetition may have improved since 2004, and a large number of students do not identify this as a problem. The Y7 and Y11 students reported very low levels of duplication, and overall this appeared to be a declining issue. The widespread use of resources intended to build on KS2 work, alongside greater awareness amongst secondary teachers, may have been factors in this improvement. The ‘spiral curriculum’, where topics are revisited in following years, covering the material in ever greater depth, would be expected to have appeared as repetition to the students. Indeed, Osborne and Collins (2000) found that Y11 students believed that their study of photosynthesis had been exactly the same every time they studied it since KS2. The low levels of identified repetition in 2008 were therefore a positive sign.

4.1.2 Summary of Questionnaire Responses

The questionnaire survey produced consistent results, either stable or illustrating a general trend. The lack of apparent random variation was sufficient to give confidence in the results, and to suggest that the students had responded accurately (without errors) and consistently (the responses of different groups of similar students were similar, and cross-checking questions confirmed this). In addition, the results were consistent with data from other schools where a number of trials were carried out in the initial phase of work in 2004, further suggesting validity to the outcomes.

If the students had been responding carelessly, or inaccurately, the responses would have shown random variations between sub-groups, and between schools. Also, responses to one question would not tally with responses made elsewhere. These issues were so infrequent as to be undetectable in the data, confirming the impression of the supervising teachers that the students had taken the questionnaire very seriously.

(a) Enjoyment of the subject

The views of students about primary school science were similar over different age groups and over time. Generally around a third of students recorded that they liked science in their primary school, and a third disliked it.

In contrast, enjoyment (as described by the students) of secondary school science was high in Key Stage 3, but declined sharply in Key Stage 4, where students became less inclined to describe themselves as 'confident' (in their terms), and twelve times as many feel that they were of below average ability in this subject. Despite this, science remained average in popularity – between 4th and 6th out of ten subjects – in all year groups sampled.

In discussions, students often identified 'practical work' as a key motivating factor in science lessons. They frequently reported enjoying the 'hands on' experience and the ability to work independently. Teachers saw a grey area where activities such as card-sorts, research, discussions and demonstrations were also described as 'practical work', the teachers tending to combine a raft of pedagogical techniques under this heading. Students were clearer in their definition of practical work, and did not include teaching techniques within the scope of practical work. In other words, the students confined their use of the term to cover experimental and investigative science, whereas the teachers included almost any activity other than the use of textbooks. The significant differences in interpretation of the term first became clear during informal discussions in lessons and were reinforced during interviews.

(b) Lesson organisation

Lesson structures, along with new teaching techniques, were a central part of the National Strategy. The 'Three-part Lesson' was a critical innovation, with an initial Starter activity, and a Plenary at the end of the main lesson activity. In the questionnaire survey, only around half of students recorded that their lessons began with a starter activity, and there are signs of a decline since 2004 when the training would have been fresh in teachers' minds. Similarly, in 2008, only four in ten students felt that their lessons included a plenary, and more often they described the lesson ending as unstructured. The students were clear and consistent in their recognition of lesson structures, and it would be difficult to attribute their beliefs to a lack of understanding of the lesson procedures.

Practical work is important for motivation and for understanding in science lessons, and is seen as the essential purpose behind science teaching. The questionnaire revealed that the use of practical work declined markedly during the five years from Y7 to Y11, possibly marking a shift from being integral in teaching to becoming an assessment exercise amongst the teaching of factual material of GCSE.

(c) Assessment
Over the same time period, Y7 to Y11, confidence in science fell, and anxiety about examinations began to climb. This was despite the availability and use of a range of revision materials and ICT resources. The students often did not feel that the teacher knew them well, but students in examination years (Y9, Y11) almost invariably knew their target grade and marking of work supplied helpful comments for many. A surprising number (approaching half) of Y11 students recorded that their exercise books were never marked. This lack of written formative assessment, in the form of guidance, encouragement, or correction of misconceptions was often, possibly always, a source of demotivation as well as lower attainment. Black and Harrison (2004) observed:

> In the main, feedback from science teachers was through marking... ...effective feedback should help the learners know where they are and where they should go next: the focus is on improvement. (p.10-11)

(d) Transition from Key Stage 2 (Y6)
Another accepted truism in British education is that Y7 students arrive at secondary school full of excitement, only to lose this enthusiasm as they endlessly repeat primary work in the first half of Key Stage 3 (see DfES 2003, pp.8-11). There are many other causes of disengagement (see Morris and Pullen (2007, p.28). The questionnaire responses supported the idea of students being interested in science on arrival, but did not support the belief that they repeated previous work to any great extent. Possibly this is a success from improved liaison and a better recognition of prior learning, (DfES 2002, appendix 1) but this finding does not therefore provide evidence to support the recent move by many schools to shorten Key Stage 3 to two years in order to reduce demotivation (DCSF 2004).

4.2 Interviews

The interviews were conducted in order to explore issues in greater depth, and to pick up on any matters arising from the questionnaire analysis. The student interviews were conducted in groups of six students, covering a span of gender, ethnicity and ability. Separate interviews covered Y7, Y9 and Y11 students. The interview questions were carefully framed to enable the students to raise their own issues, while allowing the researcher to follow broadly similar pathways with the different groups. The questions were posed informally, as if in conversation, to create an atmosphere where the students felt at ease and able to respond in confidence. Indeed, confidentiality was stressed, to encourage the students to respond without fear that their views could be attributed to individuals.
The interviews were transcribed verbatim, and analysed for themes and for significant individual comments.

The group interviews were semi-structured, permitting the students to follow their own thinking and areas of interest, with a periodic redirection or posed question to bring the discussion back to cover the areas of research. This format allowed the interviewer to explore more deeply the areas of interest to the students, and also to pick up on unexpected issues

4.2.1 Student interviews

Interviews with students in Years 7, 9 and 11 were conducted in an environment and format that would encourage the students to discuss their views openly and freely. Nevertheless, there was an issue of student maturity, which resulted in the Y7 interviews being ‘hard work’ for the interviewer, and the dialogue being elicited with some difficulty. In contrast, the Y11 interviews were fast-flowing and very rich in the depth of responses.

The interviews were transcribed verbatim (see Appendix 2) and coded for emerging themes. The semi-structured interviews allowed coding categories to be established for some predictable themes, but others developed during the analysis. Thematic analysis, and the assumptions it contains, are described in Gomm (2004, p.196). The analysis of the interviews with different age groups of students produced essentially common themes, with rare instances where one group raised a unique theme.

The eleven initial themes were reduced to five key themes, which will be discussed in detail. These key areas were:

1. Feelings about science, positive and negative, and reasons for enjoyment of the subject.
2. Perceptions of science (in school, and more widely)
3. Barriers to enjoyment of science as taught in the school.
4. Use of Strategy pedagogy in lessons
5. Science within the education experience of the students.

Where quotations are given in the following analysis, students are indicated by letters (A-F), and the interviewer is italicised. The groups were selected by the school to contain a mix of ability and background, but these details were not supplied to the researcher, and nor were the names of the students.

Theme 1 Students' feelings about school science.

This theme covers the feelings of students, positive and negative, towards science as taught in the school. The students showed high levels of agreement within each group, and frequently the same issues were also identified between groups.

1a Positive feelings towards school science

Applying coding to interviews of identical length and structure, Y7 students made 19 discrete references to enjoying science, Y9 made 12 references, and Y11 made 8 references. This pattern reflected the decline in enjoyment revealed within the questionnaire survey, and was reinforced by growing disillusionment shown in other responses. The students identified general reasons for enjoying the subject, and with greater maturity they moved from the broad sweep through to named topics, and finally to the personal activities of involvement and creativity:

> C: I like it in our class 'cos like no one messes around and we always do experiments which are really interesting.
>
> D: I like it 'cos- because it's quite challenging, (*mmhmm*) and um, you're not bored and you're always focused… (Y7)

These Year 7 students identified interest in the subject matter but also linked this to engagement and good behaviour. A Year 9 student distinguished between aspects of the subject content:

> D:I think science is quite good, except the bits where you do like stuff like blood cells or whatever – where it's quite boring.

Two Year 11 students articulated their interest in 'hands-on' practical work, and their frustration that this aspect could not be expanded. They identified the practical element as being the defining characteristic of school science:

> D: I like creating things too. Like, in chemistry you get to create like new little chemical things, all the colours coming up, fizzes, it just makes it more fun to learn. Like when you put the lighted splint in it, pops, you see that's, I think that's the best bit.
>
> B: I think if you get involved with the science, if its actually you involved with the science, and you doing it, it makes it more interesting, rather than sitting down having to learn about it.

This student had clearly been sufficiently frustrated to ask their teacher about the lack of opportunity for practical work:

> B: Because I know I've sat down with a book, doing questions, and thought "Why can't we do this?" And the teacher said "Oh, there's not enough time" Well, then it should be planned out that you can make enough time to do different….I think if there was….more.. more practicals, it would become more, you think, I've got a practical to do in science, because after all that's one thing about science, you don't do practicals every day.

In addition, the student could identify that school science offered opportunities that could not be replicated after leaving school, unlike sport activities, for example:

> B: You may have PE, you may be playing basketball, you may play basketball every day of your life after school, but I know I'll never do an experiment, say magnesium and popping it, and lighting it on fire and stuff. So I suppose if you are more involved with the science it would make it more interesting.

In these and other comments, students were able to identify particular characteristics within lessons that created the environment where they could enjoy science lessons. These features of the lessons *per se* included:

- Challenge of new and unusual topics, including some intellectual difficulty rather than routine repetition.
- Opportunities for creativity in a practical sense, and also within teaching styles – thus including debates and discussions.
- A lack of disruptive behaviour, which in itself can be a product of disengagement, and thus is a tautological factor.
- Opportunities for hands-on 'real science' where it is possible to act as professional scientists are believed to do.

These characteristics will be discussed in more detail below.

The perceptions of students appeared heavily influenced by their expectations of school science on entering secondary school. The majority of students were often able to link their enjoyment of the subject to certain iconic activities, such as the traditional introduction to the Bunsen Burner at the start of secondary school, and their first opportunity to carry out dissections. An excited Y7 student described seeing another class doing a dissection:

> A: ….'cos yesterday when I came up to get a drink of water, sort of that class were doing an experiment…these… all the other classes, like nice and quiet I don't hear nothing from them, they do like, actual disgusting science as well, like Miss R's class was dissecting this sheep's heart the other day, and we were just sitting down doing, writing on worksheets.

Another Year 9 student also identified dissection as an exciting thing that he would like to do:

> B: I think in biology we should like – you know we're doing, like, we're doing, for examples of…of anatomy, I think we like should have, probably like, a foetus – no not a real – like - a pig probably, then we can study like – *how do we cut* this organ – and like – neatly and like which one's which, and like…yeah.. and *actually touch them*.

The student significantly mentioned dissection of something relevant to their own body, rather than suggest a plant or invertebrate. They also used two expressions (italicised) to indicate that they wanted hands-on experience, rather than observing a demonstration or video.

When asked about their expectations of secondary science when first arriving at the school, the Year 11 students revealed that they had felt great excitement and the belief that their science would enter a new level of interest:

> B: Amazing. God's gift
>
> C: These things, like Bunsen Burners, gets you really interested.
>
> B: I remember. My first lesson was sat down, ...and they pulled out a Bunsen Burner and I thought it was Christmas, because you're not used to it, it's a new environment, it's a new environment, same way if you was into football and you used to play just a little bit, and then someone takes you to a big stadium and says there you go play here, you'd say "Waaah, I've just hit the lottery".

During the interviews, it became clear that the students expected that the secondary science course would prove to be motivating and would engage their interest. They were excited by the autonomy and new approach:

> A: ...we went into Mr. X's class and it was every day we had him he was doing an experiment, so he was using them, the other time he was doing an experiment every day and he was saying "this equipment isn't mine, it's yours" and…like…other classes…it's just worksheets (Y7)

The students were clearly excited by the practical activities, and by the autonomy within these experiments. They wanted engagement and personal involvement, rather than passive learning.

The students identified frustration at reading about experiments but being unable to do them for lack of time. Undoubtedly, there were other contributory reasons preventing practical activities from taking place, not readily identified by the students.

Significantly, their interest in science appeared to concentrate almost exclusively around the practical work, and not around the nature of the subject matter. Students rarely indicated interest in scientific ideas or applied knowledge. Instead, the hands-on nature of science was the key motivator:

> A: ...when I came in that science class that one time... because I didn't know what lesson I had, I said "Sir I don't know what lesson I have" and he said "just sit down there then" and they were doing an experiment, and they had a big plastic thing between the pupils and sir… it was just like, a bottle – it wasn't Year 7, that class it was Year 10's, no it was Year 9's, and sir basically tipped this thing into there, it was sizzling, sir backed away, and then all of a sudden it just went "bang!" up in the flames, the flames went all up in the air, and I was like – "I want to do that" (Y7)

Although it is unrealistic to imagine that every lesson could feature this type of experiment, it is clear that these activities are memorable and motivating. By Year 9, the students are able to articulate the power of practical work to support learning:

> A: I like experiments because I think they help us learn more. ...Yeah you actually do it yourself, you don't have to sit there writing down things that you never actually did. (Y9)

By Year 11, this appears to reach a peak of frustration, where the emphasis on learning for the exam has – in the eyes of the students – caused a change to teaching styles that are ultimately demotivating, if not counter-productive:

> E: I like doing experiments, because you learn how to do them, but when its just copying out of textbooks, its boring. Just plainly every single lesson we do it. (Y11)

Students of all ages appear able to distinguish between practical experiments in science and active teaching strategies that may include a hands-on element. The students in these interviews and in classroom conversations were clear that they did not include organised group discussions, for example, in their interpretation of practical activity.

The role of practical work as a teaching tool has been examined by several authors, and some of these studies raised questions about the effectiveness of investigative practical activities as learning strategies. Although the students found "...practical work relatively useful and enjoyable..." (Abrahams and Millar, 2008, p.1946), it was recognised that many simply preferred it to alternative forms of teaching (Abrahams, 2009, p.2349). This same research identified that students developed a short-term situational interest in their practical science, but that this interest did not endure beyond the end of a particular lesson. To some extent, the practical activities were used by teachers as a 'coping strategy' to deal with disaffected students. The teachers did not feel that students learnt any more from the practical than they would have done from a taught lesson.

These results from the work of Abrahams and Millar were able to explain the apparent contradiction in the attitudes of students in the Ashbourne School case study. Students were very clear in their excitement about the practical work, and made evident their desire to do more hands-on activities, and yet relatively few of them went on to take science subjects post-16, in the Sixth Form. Their interest had been stimulated lesson by lesson, but they had not engaged any enthusiasm to study science any longer than necessary.

Despite the firm views that practical work was the main interest in science, some students expressed a desire to do more written work. However, students called for more variety in the written work offered, rather than constantly writing up the method and results of experiments. The following exchange, in response to questions about writing in science lessons, demonstrates that some Y7 students would like to do more writing:

> E: We don't do much writing in our class – we do only experiments but I'd like to do more writing.
>
> A: We do way too much writing. … if we don't do experiments we do writing, if we don't do writing we do posters, we don't, we've made quite a few posters I actually prefer to do posters or ex..practical, it's really…
>
> E: I think we'd like to do experiments and writing, not too much of one of them... ...Mainly writing up experiments.

The Year 7 students claimed to be keen to write, provided that this had a clear purpose, was varied, and was balanced with practical work. Year 7 students frequently identified that where their work was linked to other subjects, this provided a focus and increased their interest. The younger students quickly noticed links within the subject knowledge:

> E: it depends what you're learning about because, I don't really like science that much but when we were learning about volcanoes I found that interesting because we also do that in Geography, but when you have to do…um… electrical currents or dissecting frogs, I don't like dissecting anything because I think that's cruel. (Y7)

The same students also picked out where they could gain excitement from other sources, such as video programmes. However, it is significant that the older students identified unifying skills (eg. Mathematical skills and application of logic) rather than linked subject matter.

> D: ...each subject's linked in a way, in science we sometimes use maths, and English does help you in your logic, I think its logic, or maths could be logic as well, but it kind of helps with your writing skills as well, which helps with the English, so I think that it helps that we have science... (Y11)

This illustrated a remarkable depth of understanding in the nature and purpose of education in a broad sense.

1b Negative feelings towards school science

The interviewed students recorded negative feelings towards science, falling into a general lack of interest in the subject, as well as specific dislikes, the latter being split into emotional and procedural dislikes. These feelings mirrored responses in the questionnaire.

The lack of interest in science, as expressed by the students, was a particular concern, since this underpins all other aspects of teaching science, and this was the particular issue to be addressed by the National Strategy since its introduction. The lack of interest, as described by the students, was caused by infrequent or irrelevant practical work, poor teaching techniques, and increasing focus on examinations.

(a) Lack of engagement in the subject matter

Many Y7 students, after just two terms of secondary science, already felt “It's not something that appeals to me.” (student E). Even practical work was uninteresting to some Y7 students:

> A: yeah cos we never do stuff like that – the only experiments – the last experiment we did was actually quite boring cos all we had to do was look at rocks. Dip them in water and see what colour they changed…

It is significant from this particular exchange that not all practical work is attractive *per se*, and that repetitive, unchallenging or apparently pointless activities were seen as unappealing. Thus, while some students grouped all hands-on investigative practical activity as interesting in their view, other students were more discriminating.

By Year 9, the reactions are stronger, and the students have identified the general subject areas where they have difficulty understanding the concepts and the relevance. The following exchange shows this:

> B: I hate physics. I love chemistry and biology... I just.. yeah I don't, I don't really get the whole point of physics, I don-, I don't get some of the points in it, I don't get some like – like why – I don't get some topics in physics, so I don't like it.

Although he found it difficult to articulate his ideas, this student significantly illustrates that the cause and the detail of the dislike is poorly understood, while the concept of the different subject disciplines within science is well recognised. The emerging dislike of physical science is important as this has for many decades been of declining popularity at university level. The current Science and Innovation Investment Framework 2004-2014 (2006) was introduced to address this very problem.

In Year 11, the students had moved on from the frustration of lack of understanding, and began to identify the causes of their lack of interest in science:

> C: I think er science in general is actually quite a boring subject. I think, I think that it could be made quite fun. I don't think teachers here make it fun, at all. I just think its ‘read out of a book and learn it that way’, and that's about as far as it goes.

This response, typical of several from this age-group, demonstrated that these students fully recognised the importance of effective teaching, as distinct from the intrinsic interest of the subject matter. In several exchanges, they identified a lack of engaging teaching in science, as distinct from a general lack of interest in the topics.

The reasons for lack of interest can be seen to vary with the age group, and these views illustrated a widely held view at each age. Initially, the students were disappointed by the nature of task given – the topics were in themselves less interesting than expected. In the quoted examples above, dipping rocks into water seemed less exciting than explosions.

At the end of Key Stage 4, the students felt that the increasing pressure to perform well at GCSE level, coupled with uninspiring teaching, led to a book-oriented approach to learning science. Typical comments in Y11 included:

> E: I just don't like work in science, because we do summary questions and we don't do no experiments, so its all in books.
>
> B: Science seems like its one thing, which is… well, maybe two, because you get experiments as well, but science predominantly is copying out of books and that, and learning from the books and we learn… you can't do practicals in lessons in history or things like that, [C: yeah] if you get a lesson where you can do practicals to learn about it, it's a nice change, rather someone shoving a book in your face and saying right…

(b) Lack of engagement in teaching styles

In addition to the lack of hands-on practical work or engaging subject matter, students also identified specific aspects of teaching that appeared demotivating. Throughout their time in school, the students commented on the limited variety of teaching styles, concentration on reading and 'question and answer' rather than engaging practical activities, and emphasis on preparation for examinations. Year 9 students described a typical lesson as follows:

> C: Get the books out. Teacher tells you what page to turn to. Read through it as a class, or read through it as a class individually, *[affirming sounds from all]* read through it as a class, answer summary questions.
>
> D: Our class reads like that.
>
> A: Our class, we have like the teacher talks us for half an hour.
>
> D: Yeah, she lectures us about exams first.

These Y9 students clearly regretted the predictability of a typical lesson, and the fact that the lesson revolved around a routine of book-related work and teacher-talk.

These were aspects that the National Strategy sought to address, by stressing engagement and a student-centred approach. In the eyes of these students, their lessons retained many of the characteristics that the Strategy had aimed to eradicate.

(c) Increasing focus on examinations

The way that science teaching changes emphasis as they progress through the school is well appreciated by the students, and by Y11 they were able to describe the changed nature of their experience in science lessons, from initial feelings about Y7. One student described declining enthusiasm over time, and a growing focus on examinations:

> B: I've just hit the lottery. And that's what it is, and it goes from that spark and then you start thinking it ain't as good as a couple of months ago, then it comes into Y8 and you think it was really good, I hope it lives up to expectations, oh hang on this is a bit…. By the time you get to Y9, you've got SATs coming up in science, all right,

> you try, you try to concentrate, and you see there's more bookwork, by the time you're in Y10 you've given up, by the time you're in Y11 you're trying to pick yourself back up, because you've got your GCSEs coming up…(Y11)

This student, having described the step by step loss of excitement, recognised the difficulty of recovering the enthusiasm for science:

> … if it was on a graph Y7, Y8, Y9, Y10 *(draws descending slope with hands)* and then its trying to pick yourself back up. Like throwing yourself all the way down and then trying to pick yourself all the way back up for your GCSEs and that, I think that's hard, I think that's where it drops, because it just seems repetitive, all the things that happen in it. (Student B, Y11)

Specifically, the student identified the increased 'bookwork' in Y9, linked to the SATs examinations, as the beginning of the decline, leading to increasing lack of engagement. The difficulty of recovering motivation for the GCSE examinations is particularly significant, not only because of the effect on attainment, but also because of the impact on choices for further study in the Sixth Form.

(d) Specific issues

The students described disillusionment in science, coupled with increasing boredom, illustrating a lack of interest which rapidly develops and becomes embedded. In all of the interviews, the students stated these views. In addition to these general feelings, the students also identified specific dislikes. Perhaps surprisingly, the most prevalent was dissection, in past decades seen as being an exciting component in science lessons. For Y7 students, the views were strongest:

> E: ...but when you have to do…um… electrical currents or dissecting frogs, I don't like dissecting anything because I think that's cruel.
>
> *Interviewer: Did you actually dissect frogs?*
>
> *(all talk)* E: I didn't want to.
>
> A: They dissected a sheep's heart the other day
>
> E: it's still cruel
>
> A: And, Grant said that he felt sick and he had to wait in the other room – cos some people felt sick in that class and that's why they didn't come out to break, because we were like "Grant, are you alright?" he said "Yeah I just felt sick, just sick from the frogs, er sheep's heart"

The issues were three-fold. The students felt that the procedure was 'cruel', they felt disgust, and they resented being obliged to participate. This interview exchange is particularly interesting. While group dissection of a heart is reasonably common, the dissection of frogs would be rare, if not unheard of, in Key Stage 3 and 4 today. However, it was a feature several decades ago, and the student was undoubtedly referring to something that they had been told to expect by their parents or grandparents. It was also interesting because it illustrated a prevalent sensitivity. Dissection, once an exciting part of the course, is widely seen by students as something to avoid.

Another dislike which featured in all three group interviews was the amount and style of writing required. The traditional formal write-up of experiments, coming straight after exciting practical work, was particularly resented. It was the repetitious style of writing that was tedious:

> D: 'Cos in so- other subjects you can do posters or you can do other styles of writing, but in science you always have to write method or briefs or…so basically it's writing the same thing over and over again. (Y9)

Furthermore, some students took issue with the very nature of school science. They disliked the supposed certainty of closed knowledge, leaving little room for open debate on accepted facts (see Kuhn, 1996). Some students, while accepting the advances made by society, blamed science for the ills stemming from technological developments. For example:

> D: I think it's bad in a way because science produced cars which are kind of destroying the environment. (Y7)

Thus, the reasons for disliking science were varied, including some factors that were within the gift of teachers to change within lessons. Other factors reflected the deep-rooted values and beliefs of society, and were therefore not readily open to modification.

Theme 2: Perceptions of science and scientists

This theme illustrated that students were fully aware of the stereotypes of scientists held by their peers and by wider society. Indeed, while they recognised the cartoon nature of these stereotypes, they nevertheless felt pressured to avoid association with science as a career. These views were present from Y7:

> *Interviewer: -, if I asked you to draw a scientist, what would they be doing, what would they look like?*
>
> A: White coat, big glasses, funny hair
>
> *Interviewer: … what do you think scientists are really like?*
>
> E: They're no different apart from what they do, 'cos my sister's going to… training to be a science teacher soon so if you ask me to think of a scientist I just think of her.
>
> *Interviewer: Why do you think that so many people come up with the vision of the scientist that you said? Why is that? Why do people think of scientists in that way?*
>
> E: 'cos when you're a child and you watch cartoons, and things, there's a scientist they're always like this crazy science person.
>
> By Year 9, the students had a more balanced view:
>
> B: ...all scientists are different. Like - a scientist could be like, inventing biological weapons and a scientist could be like, if, like inventing a cure for like cancer. How do I say it… some of them are good, like, and some of them are bad.

Despite the apparent 'balance', the examples quoted still reveal extreme views of what scientists actually do. The examples do not encompass the vast range of typical roles of workers in scientific disciplines and allied fields of work.

However, in Year 11, the students were clearly grappling with conflicting views, with a contrast between their superficial, stereotypical view of scientists, which they would express with their peers, and their deeper understanding of the actual status, role and appearance of members of the scientific community. This is well illustrated by the following discussion:

> *Interviewer: What do you think of scientists? If you thought about a scientist in the outside world, what kind of image comes to mind?*
>
> C: A man, in a white jacket, down to the arm, with glasses on, looks like a right nerd. [All laugh]
>
> D: That's Einstein, frizzy hair.
>
> C: (points to picture on wall) Looks like that.
>
> B: I think of someone exactly stereotyped as well, and that, I think of someone that likes science, who is trying to make a difference to the World, but had more of a push, that was their thing that they were going to do.

> C: You think of someone who actually has no social life [B: You do, yeah] that's what I do think of.
>
> B: See me, say I…say I want to push with Business Studies. I can see me with a briefcase, suit, shoes, sunglasses, Bluetooth headset, whatever, what have you, and people may think oh he's just a bloke who's doing business all the time, but that's something you want to do, you want to push for. If you want to do something, you'll keep going, go for it, same way if you want to be an actor, you might see someone in not, not the bestest clothes, [D: All black] but they're walking around, trying to find that part. The scientists are now trying to find where they want to be, so I do, I do give respect to them, because it's a tough job, but someone's got to do it.
>
> E: Its people like Steve Hawking trying to like unravel the Universe, and how it started, and that.

At this point in the interview, the prevailing stereotypes were challenged, to explore whether the students held the views firmly or whether the image was recognised as being a caricature:

> *Interviewer: Most people have this, kind of, stereotype image of a scientist, exactly as you described, OK, a bloke, little round glasses, probably on his head white coat, pens in the pocket, OK, ambling around, clipboard, no social life, bit of a nerd, OK* [C: Always spends his time in a laboratory] *and, and, socially inept, probably doesn't have a girlfriend, etcetera, etcetera. OK. Now do you actually think scientists are really like that, or is that like a kinda joke stereotype, but deep within you, you kinda know that isn't true?* [All nod, yeah]
>
> D: Yeah, I know that isn't really true, but when we were younger, that was our stereotype, that was all we knew. But now in modern day TV, you see more scientists on TV, I don't know, for example CSI Miami, but you see them in a lab, and they aren't ugly, they all look quite good looking, they don't have big frizzy hair, glasses, but that's probably how they look, normal people...
>
> A: There's different types of scientists. So I think there's like the extreme scientists who really really love science, and other ones who only do it for a job.

The Year 11 students were able to reflect on their own experiences, and relate their views of science to their current and future lives. The developing views about scientists, and their role in society, are extremely important because they illustrate maturing ideas at the point where students would be making decisions about their further study and career options:

> D: If you think about it, we're all scientists in our own way. Because when we're little kids, if you remember, we used to explore our own world, we used to dig in the ground, we used to see what's inside the ground, and that's what scientists basically do, they observe the World, they make things, they look at things, so we are all basically scientists in our own way.
>
> B: One of, if not, nah I wouldn't say THE most, but I think one of the most important things that you need to know about. Because if you go and say I remember science, I used to hate science, but there's stuff that you know that's in your head, and so if anything did ever happen, you think oh I know why that's happened. And I think it will just pop up and you don't know. Some things will just happen and you remember, oh I know what to do in this position, so I think it does pop up when you don't realise it. [Yeah, yeah]
>
> C: Nearly everything you hear on the news relates to science, everything, everything, in the long term relates back to science, if you look at it in perspective everything goes back to science, there's always science involved in something, whether its that computer over there, or this floor over here, its all been chemically bonded, all things like that, you know what I mean….

This exchange is highly significant because it explores the growing awareness of a wider importance of science beyond the classroom content. The students are conscious that they are all using scientific skills, that scientific ideas are useful in the real-world contexts, and that science is an important subject within the curriculum. The Y11 students made frequent references to television shows (eg. CSI Miami) and to local influences, such as the introduction of ultrasonic Mosquito devices to deter youths from loitering (see APPE 2008). The students were thus able to identify perfectly clearly the external influences that moulded their perceptions of science and their attitudes toward studying the subject at school. Significantly, they did not quote examples from lessons and did not refer to topics raised in class. This would seem to indicate that the National Strategy has not been the most significant factor in shaping the attitudes of students toward science.

The perception of science as a difficult subject (Coe *et al*, 2008) can be strongly influenced by parental views, as in the case of this Y7 student:

> A: Yeah. We never really have homework, and once we got homework and I took it home to my dad, and said “Dad can you help me?” and he said “I hate science” and plus “I don’t understand a bit of it”.

Another perception held by some students was that science as taught to them in school was not relevant to their lives (Jenkins and Nelson, 2005). This is despite the views of many Y11 students that the skills of science, in particular, were extremely valuable in life (see above). In Year 7, the students held strong views about the relative importance of science in the curriculum:

> C: Um, not as important as like Maths and English because you need it like every day, (A: you need them) but in science like, every day you’re not going to like talk about rocks or chemical reactions or anything, so it’s pretty different.

Similarly, the Y11 students felt strongly about what should be included in their science course in order to make it more relevant to their needs:

> B: …we’re just doing a project about polymers and stuff like that...I don’t know what I’m going to use that for, I don’t know in my future life what I’m going to use polymers and whatever their called for. And it just seems if we <u>are</u> going to learn it, spend less time on subjects like that, and more time on more important subjects...
>
> C: ...That you need to know.
>
> B: Yeah, like the, like the Global Warming and stuff. We do, it does come up in a unit, we get told so much about it, but there’s no-one doing anything about it really, so then we think to ourselves: why are we learning this? This is stuff that we know. And a lot of it does seem to be going over stuff that we have learnt…

The students referred to Global Warming on many occasions, and it was clearly a topic that interested them. Certainly the topic is a current issue, and the course did therefore cover topics that would affect the society in which the students find themselves. However, they preferred to discuss this topic, rather than carry out laboratory experiments to explore the possible effects of climate change. This suggested a different format for learning science, since the students expressed a desire to discuss scientific concepts within a wider context. Once again, their preference was for open discussion rather than closed ‘scientific certainty’ as they interpreted the approach in their lessons.

The apparent paradox – preferring to discuss some issues rather than do experiments – can be explained by considering the clear partitioning of knowledge in the minds of the students. Where the purpose of the lesson is to ‘learn’ accepted facts or to take measurements, the students had a clear preference for hands-on activity rather than just being told the answers. Where the issue involved scientific uncertainty, dispute, or social implications, then students preferred a discussion or debate model for the lesson. This would allow the students to explore their own thinking and evaluate the ideas for themselves.

The students also recognised the need for wider general knowledge, and during the interview Y11 students were able to reflect on the value of the knowledge that they had accumulated:

> C: It's quite funny though because as we say it, I look over there and I look at all the plants and they are facing towards the window, and its like, well I only know that because its science, it gets attracted towards sun, creates photosynthesis, etcetera, etcetera [B: Well done; *all laugh*] so if someone was to ask me, so I could tell them, its general knowledge really, it does help you out a lot in life, like how to grow plants, and stupid things like that...[*All laugh*]

The standing of science, and hence the attractiveness of the subject, is affected by the use to which it is put. The ethical issues of science in everyday life were important to the students, and one Y7 student compared the role of science in developing new technologies and applications, such as rockets and cars, against the 'bad things' such as nuclear weapons.

The uncertainty of science, and the shifts within scientific understanding (see Kuhn, 1996) are aspects that the students found difficult to accept:

> E: ...depends *(depends ok)* well its good like when they try to work out how to cure cancer or something, that's good, I don't, I don't know how to explain it, it's just sometimes it's not as good as it should be, like sometimes they're not certain, like with evolution they think we came from monkeys but I do not see how that works out, or when they used to think that the atom was the smallest thing until they split it open, like there's sometimes they think they're certain but they're not….. (Y7).

This student wrestled with the idea that 'facts' can change or may be difficult to accept. Atoms are no longer the smallest particle. We evolved from Primates. Science can't cure cancer. In the mind of this student, scientists are expected to have the answers and when they don't, 'it's not as good as it should be'. Some of this was 'troublesome knowledge' (Hall, 2006).

The way in which science is presented at secondary school level, and the way in which it is examined, presumes a base of known or at least knowable scientific facts. For teachers or educationalists to question the factual or philosophical basis for school science is to invite pressure from the scientific establishment (for example: Royal Society 2008, responding to proposed discussion of Creationism in science lessons).

Theme 3: Barriers to enjoyment of science

Students in all groups readily identified two issues related to the teacher in front of the class. The students recognised the impact of teacher turnover – changing their teacher in the middle of an academic year – and the ability of the teacher to form good relationships with the class. Significantly, the students did not mention any issues related to teacher knowledge of the subject, but they were extremely vocal about the lesson style. The importance of this point is that the background and experience of teachers in the field of science would be more difficult to address within the profession than would be a change in pedagogical techniques. This endorses the aims of the National Strategy, where emphasis was placed on teaching approaches, rather than giving the teachers more profound subject knowledge.

The issues identified by the students are likely to be exacerbated by the shortage of science teachers, where schools have little choice about who they appoint, and where teachers may be on temporary contracts. The principal aims of the National Strategy for science were intended to improve the way in which the subject was put across in the classroom. These aspirations for improved pedagogy were not universally embedded into practice, according to the Y11 students:

> B: I think science can be good but teachers need to put more effort into it...
>
> C: Yeah
>
> B: ...and it should be more of an option, because I know out of English, maths and science, science is the worst. Like that's my opinion, it might be other people's opinion as well. I just think if its going to be one of those essentials, they need to make it like better…
>
> A: We get dictation, lectures and stuff. Sometimes we get shouted at and then...
>
> D: ...she'll talk about the work...
>
> A: ... she'll talk about the work for ages, and then we get told to do all the questions, and then summary questions...
>
> B: Yeah...
>
> D: ...summary questions we get like ten minutes to do, because she's already spoken for all lesson...
>
> A: ...copy them….
>
> B: I think really it's down to teaching styles... different ways of teaching, rather than just teacher at the front – obviously they've got to be at the front, they've got to tell you what you're doing – but rather than the teacher keep talking and talking and talking – that's usually what our typical lessons are like, teachers basically telling what we're doing, and then you doing it. It just, like, just drags on, and you think oh, I've got to go in and do the same thing over and over again.
>
> C: ...it is just exactly that.

In referring to making science an 'option', the student at the start of this discussion implied that the quality of teaching in science was so poor that the subject should not remain an essential component of the compulsory 'core' curriculum (considered to be English, mathematics, science). This is despite other Y11 students recognising the great importance of the subject.

The students referred in this discussion to individual teachers, but it was clear that all of the students, selected from different classes with different teachers, had broadly the same experience.

Theme 4: The use of National Strategy pedagogy in science lessons

Foremost amongst the aspects of the National Strategy, new teaching techniques were introduced as a means to promote improved engagement and learning. Extensive training, supported by a wealth of resources, was provided to raise awareness of the value of structured lessons in raising students' interest and reinforcing the learning process in science. The main features included 'three-part' lessons, with a starter activity, main part to the lesson, and a plenary at the end. Other aspects of improved pedagogy included improved questioning, awareness of student misconceptions, and greater use of group work.

When interviewed, students showed an awareness of structured lessons from other subjects at school, but felt that the starter and plenary were not used in science lessons. For example when asked about starter activities, the Y7 students responded:

> A: Did you just say in just science or do you mean in all subjects?
>
> *Interviewer: Well, it's supposed to happen in all subjects but..*
>
> A: Well we do have them in other subjects, a quick activity to start off the lesson…
>
> *Interviewer: Yeah, I mean like, these kinda starters at the beginning of a lesson they're supposed to…*
>
> A: Get your brain in gear?
>
> *Interviewer: Yeah exactly that, exactly that. But you don't recognise that as happening in Science*?
>
> B, E: No!
>
> *Interviewer: Now, when it gets to the end of the lesson, how does a science lesson usually end?*
>
> C: Like if you've done an experiment you have to write a conclusion for it, and if you've done a worksheet you have to write what we've done today.
>
> *Interviewer: Right OK. So you write that down on the worksheet,*
>
> A: Normally. Normally in my…our science class, when the buzzer goes, everyone just runs out, leaves their stuff on the table and runs out.

At the risk of a 'leading question', it was important to explore whether plenary sessions took place:

> *Interviewer: Sure. Do you think that, well, at the end of a lesson does a teacher ever sort of say "Right OK, let's just talk about what we've learned today"? Does that happen, no?*
>
> E: Sometimes
>
> A: Never in my science class....
>
> A: Sometimes in different classes, like technology we have to, a beginning and an end – "what we're going to learn today, what did you learn today?"

This student clearly referred to lesson objectives and a plenary to discuss the outcomes. The aims of the lesson can be described by the teacher as WALT (We are learning today...) and WILF (What I'm looking for...) and the student appeared to describe the use of this technique which had been part of the National Strategy.

The Y7 students therefore had a clear understanding of the meaning and purpose of each part of the 'structured' lesson, but they reported that this style of lesson occurred in other subjects but not in science on a regular basis. It would seem that the training on effective teaching styles had become more firmly embedded in other subject areas, possibly due to factors such as staff turnover and shortage in science, and perhaps also due to a traditional emphasis on the delivery of science 'facts', rather than the development of deeper understanding.

The Year 9 students had even less experience of a structured approach in their science lessons. They described lessons where the start of the lesson involved writing down objectives for their learning, and then the teacher would talk for 40% of the lesson, in their estimation. The Year 11 students recognised the calming effect of starter activities, rather than their role to develop thinking or review of past learning:

> B: But even so, with starter activities, because we do have some, usually people come in, depending on like what period the lesson is, it will be like, everyone's *overexcited*, or they're being loud. Even if its just ten minutes at the beginning, say its just something on the board, even if it's just there and that ten minute period is just

> for everyone to calm down, set their mind into gear, “Right, I’ve got to do science now”, and I think out of the ten minutes maybe it should be like a five minute game or something and five minutes to get everyone settled first, because I know a lot of our class we come in and we’re rowdy and then Miss gets annoyed…

When asked about the frequency of starter activities, the Y11 students were very clear about how often they had learning starters versus ‘fun’ starters:

> *Interviewer: I know this is hard, but what percentage of lessons do you think, in science, have some sort of starter?*
>
> D: Do you mean fun starter, or just general starter?
>
> *Interviewer: Just general starter, some activity at the beginning*.
>
> B: Fifty-fifty for us...
>
> D: 55% for us [general laughter]
>
> *Interviewer: OK sure, about half. Something like that, OK. And in terms of a fun starter, because you differentiated that, how many do you reckon have something fun at the beginning?*
>
> E: Not a lot
>
> A: One a month
>
> B: About five in the whole year
>
> C: Yeah probably

Despite the expectation within the Strategy that all lessons should be structured to include a starter activity, it is clear from the students’ claims that this aim is not being achieved. They estimate that half of lessons begin with some form of starter, and fun activities are infrequent.

Similarly, the Y11 students had a very clear idea of the frequency of plenary activities, and as with the Y7 students, they could see that these activities happened more in other subjects:

> C: It never happens.
>
> *Interviewer: It never happens? [all shake heads] OK, right.*
>
> C: In other subjects, yeah, but not in science.
>
> *Interviewer: In other subjects but not in science? That’s quite critical…*
>
> B: Sometimes it does happen with us, but that would be like two minutes before the end. And then like the buzzer..
>
> C: the buzzer’s going…
>
> B: and then the buzzer goes, and we’re still talking and we’re thinking come on we’ve got to go, we’re getting out of science, can we just go to our next lesson [C: Yeah] and they just drag it on and on and on. So if they were to do that, it would be good to do it ten minutes before [C: ten minutes] not ten minutes after.
>
> C: It never happens really. How often does it happen with us? Hardly ever.
>
> *Interviewer: Hardly ever? Right*.
>
> C: In other lessons it does, but not in science.

The overall impression given by the students of all three age groups sampled was that the lessons rarely followed the ‘three-part structure’ that had been a central feature of the National Strategy training. As for the other features of the training, including the use of frequent questioning and group activities, for example, there was little evidence of any movement away from ‘traditional’ teaching styles. The most common pre-Strategy teaching methods tended to focus on more didactic approaches, with techniques aimed at delivery of a body of knowledge. Many teachers resorted to these methods when under pressure to cover the syllabus, or where class behaviour was challenging. One Year 11 student recognised this in stating:

> D: I think our teachers are set in their comfort zone, and are scared to go out of that comfort zone. Because they're so used to doing things with a ritual, they're so used to doing things… They're frightened that if they do go out of the box [C: Change] we won't learn…

Theme 5: Science within the education experience of the students

The attitudes of students towards science are profoundly affected by their prior experiences of science, and by the relative enjoyment and interest in other curriculum subjects. If a student had experienced poor outcomes in primary science, or if they had a relatively more positive experience in other subjects in their secondary school, then these factors could lead to negativity in their secondary science. The aims of the National Strategy for Science included steps to make secondary science more engaging and varied, in order to counter these issues.

(a) Comparison with Primary Science

The Year 7 students had a recent recollection of their primary school experience. They recognised that science in secondary schools had become more challenging, but they dismissed their primary science on the basis that experiments weren't 'proper science' in their eyes:

> A: In year 6 we never did an actual proper experiment with electric or fire or anything like that, we just…like…made…this thing with papers, I don't know what it was… it was like mostly concentrated around that, a globe or something…I can't remember what it was called...

The Y7 students could recall specific science topics and activities with great difficulty, and could only remember scattered experiments that were interesting at the time. They did not recall the underlying science behind their activities. These students, just two terms into their secondary school, were not able to put their primary school experience fully into perspective, but they could already detect the changes in the level of difficulty:

> C: I thought it was actually quite good because it wasn't that hard, it was quite easy, but now we've got here it's getting more challenging, so that's probably why most people are like..(trails off)

In contrast, the Y11 students were reflective about their experience in primary school, and they were able to articulate their frustration and disenchantment with secondary school science. Despite the aspirations of the National Strategy, the students still experienced the loss of motivation within Key Stage 3 that had previously been identified (eg. Galton, Gray and Ruddock, 2003; Morris and Pullen, 2007).

> B: I was looking at my old book from my old school, and I was really good at science, I must of really liked it and the stuff we used to do. And I don't know what's changed, it seems, as you get older…when you're younger you get really excited, and in Y7, Y8 you get into a lab and think right I'm not used to this, I'm used to tables and a little… I don't know, little experiment we may do "how does Coke fizz?" or something in your old school.

The student reflected back to their primary school experience, and their enjoyment of simple experiments carried out on classroom tables. This is followed by an excitement of moving into a laboratory, though the novelty soon wore off, and they began to question whether further study would be enjoyable:

> B: And you come into a new environment and you think to yourself, 'Yeah, right', as you keep going with that same environment, and things start to slow down, and you think "Hang on, its getting a bit boring now, and I don't think taking it in…." ...someone saying to you "Would you do this in the sixth form?", ah you think is it going to be the same, I haven't really worked as hard. ... ...But then I thought to myself "Hang on, did I enjoy it? Did I enjoy it before? Did I put in enough effort before? Did I learn what I needed before?" And it's a case of, at the time, you're maybe thinking "Oh, I can't be bothered and I'm just going to get it done and out of the way".

This student clearly wondered whether the decreasing interest would continue into post-16 courses, and concluded that it would be better to end their study of science as soon as possible.

The Y11 students recognised, within this discussion, two factors of importance. First, that if a student had aspirations to use science in their career, they would ride through the disenchantment, and second, that the 'book subject' nature of secondary science was causing much of the lack of interest:

> B: And if you want to after, that's your prerogative, but I think if you want to do science, you'll do it from beginning to end [C: Yeah] and you will keep pushing at it, same way if you're into acting, you'll push forward and keep going in the sixth form, business, and any other subject.
>
> A: And if science had come across as more than a book subject from the beginning, from Y7, then more people would be inclined to do it at sixth form, because they would be more interested in it.

These Y11 students reveal that their experience of science education has not been encouraging. They looked back with a certain fondness towards the simple experiments in their 'old school' – their primary school – and reveal again their disappointment with their secondary science. The growing disenchantment clearly affects their choices for sixth form education and beyond. Some primary schools clearly provided engaging activities:

> E: It was quite interesting because we mostly done practicals at our school, we learnt about plants, and we went to the darkroom and put all stuff, and we went and done photos and all that.

The students recognised the limitations of the types of activities that primary schools could provide, but they also identified the need to capitalise on the 'mystique' of secondary science.

> B: ...but obviously you can't put all these big experiments into primary schools, but if you keep them guessing, keep them coming, and as soon as they come in to secondary school, they will enjoy it. So maybe it weren't that good in primary school......?
>
> C: It's got to be from, it's got to get interested from the day you join, I'd say from the day you join secondary school, or maybe Y6 or Y5, it's got to be interesting from that day to the day you leave.

They also identified the effect of examinations on the way in which science is taught, which influences the way in which science is presented at secondary school:

> E: When you do science in primary school, you don't actually need to learn a lot, but when you get to secondary school it's all dumped on you with these exams and that [C:Yeah] Gets much harder, you come into the real world in a few years.

The Y11 students were thus able to reflect on their experiences over primary and secondary science, and could identify the factors that influenced their engagement with the subject at different stages. Initially, they were interested by the novelty of hands-on practical experiments in Key Stage 2, and they looked with anticipation to their opportunities for more sophisticated work at secondary school. Quite quickly this was replaced by disappointment as the subject in Key Stage 3 proved more humdrum than they expected. Finally, the pressure of examinations, particularly as this affected the teaching approaches, caused a sense of demotivation. The views expressed by the interviewed students appear to be supported by other lines of evidence.

(b) Comparison with other subjects

The students in Y7 felt that visits, after-school clubs and other activities outside the classroom would help them develop an interest in science. The students did not feel that the school provided these opportunities to the same extent as was found in other subjects. The older students did not have these opportunities either, but they did not identify them as an issue. This could indicate many things, including lower expectations for these extra-curricular possibilities.

When asked about subject preferences, students almost invariably mentioned subjects with a practical or creative element, as opposed to those subjects with a large written or factual component. For example, the Y9 students, relatively untroubled by the needs of future study or employment, were able to identify their preferred subjects:

> B: I like food tech, art, and music. (ok) food tech because I love cooking and I like designing the the presentation of cooking. Art because we're doing clay right now so it's… it's fun because it's messy and you get to throw clay at people…. (D: we don't) and then music because, because, I don't know -people - the teacher says I'm good at it so- so I like it
>
> D: I like drama because it's like, practical and I'm really good at it, and music, I've been involved in music for most of my life, because of my Dad and my Uncle, and things like that
>
> E: I like P.E because you get to play sports with your class, and learn how- new rules and stuff

Above all else, the students recognised that the quality of their experience, whether in science or in other parts of their school curriculum, depended on the quality of the teaching. The students in Y11 could reflect on their teaching, and revealed that they could identify good techniques. The students were not the passive recipients of education that teachers may believe:

> *Interviewer: How do you think lessons in science compare with other subjects? I mean, are there other subjects that you would describe as boring, like you describe science, or are other lessons in the school actually a lot more fun? How does it compare?*
>
> C: Some of them are good, some of them are boring, it depends what lesson you're in. It totally depends what lesson you're in, what teacher you've got.
>
> B: D'you know, that's what I think it is. I think its down to the teachers really. Because I know, I've had different maths teachers, some maths lessons have been come in, and like mellow talking, mellow talking with like each other, my maths lessons now we go in, be quiet, we do the work [C: So quiet] in silence, and I think it is, I think its down to the teachers. I reckon science, more people would enjoy science, but I think its different teaching techniques or whatever need to come in. But I think obviously you can't be like, oh, everyone talk, do what you want, we're not going to learn science, obviously you can't do that. That's just not necessary at all. I think there should be a time where, maybe a student teacher shows how different ways you can do it, and how you can make a lesson fun.

C: It totally depends on the teacher and the subject.

D: Its also personal choice [C: Yeah]

It is significant that the Y11 student B suggested that student teachers should demonstrate different ways to teach. The implication was that the more experienced teachers had become less innovative and less open to new techniques. However, there is no specific suggestion that the situation in science is better or worse than in other subjects.

The overall picture shown by the student interviews is extremely coherent, in that the views of individual students tend to reinforce each other, rather than show disagreement. The opinions demonstrate that attitudes towards science are not positive, and actually decline during Key Stages 3 and 4 (ages 11-16). In this school, few students elected to take post-16 science courses. This picture of a decline in attitudes, beginning in primary school, and affecting girls to the greatest extent, is widely documented (eg. Barmby, Kind, and Jones, K., 2008) and appears to be widespread in British schools to have worsened over time (Osborne, Simon and Collins, 2003).

The student interviews also suggest that teaching styles have not embraced the techniques and concepts that were central to the National Strategy, and that the content and style of lessons are not effective in engaging their interest.

4.2.2 Teacher interviews

Introduction

The interviews with teachers were conducted individually, in private rooms, during summer 2008. The aim of the interview process was to explore the views of the teachers regarding the National Strategy, student attitudes, and their own current practice. The views expressed by the teachers were compared with the views of students and the observations in lessons, in order to explore any differences.

Four teachers from the department were interviewed: the Head of Science, an older experienced teacher, a young teacher, and a newly qualified teacher. In addition, interviews were conducted with two other heads of departments in 2004, at a time when the National Strategy had recently been introduced. A teacher with experience of both primary and secondary science was interviewed to give an insight into transition.

As with the student interviews, the teacher responses were analysed by identifying themes and reducing these to key areas. This process proved more difficult than with the students because the semi-structured interview process became diverted where teachers had particular points that they wanted to make in the interview. Because of the relationship between the interviewer (a Local Authority Adviser/Inspector) and the teachers in the school, it was important to recognise the potential for the interview to contain bias (see section 3.2). The teachers were individually reassured that the interviews were confidential, and that the interviewees should speak freely. The purpose of the research was explained at the outset, and participation was voluntary.

Themes

The principal issues raised in the teacher interviews fell into the following themes:

- The style and techniques in teaching
- The quality of teaching and learning
- Support to raise the effectiveness of teaching
- Barriers to further improvement of teaching
- Student attitudes and the factors that affect engagement in lessons

The teachers were generally reflective, and considered the broad factors that made their teaching more or less effective. However, they rarely explored causal links and underlying reasons for their experiences.

(a) The Style and Techniques in Teaching

The main features of the National Strategy included guidance on the most effective teaching styles. These were developed in a series of training opportunities offered to schools in the first three years of the National Strategy, and were summarised in Pedagogy and Practice: Teaching and Learning in Secondary Schools (DfES, 2004), a pack of twenty training booklets commonly referred to as the 'Ped Pack'. In addition to this general guidance, the National Strategy for Science provided specific training on issues related to student understanding of science issues. In 2004, interviews with Heads of Science in two contrasting schools revealed a comprehensive understanding of the principles and awareness of the recent training (see appendix 4).

Participating teachers, 2008 interviews:	
Head of Department	Female, nine years experience
Experienced teacher	Male, mid-career (15 years teaching)
Young teacher	Male, early career
Newly Qualified Teacher (NQT)	Female, first year of teaching

In 2008, interviews of staff revealed a different picture. Certain of the ideas put forward in the National Strategy had become embedded. Most readily associated with the Strategy is the three-part lesson, including a starter and plenary session either side of the main activity:

> ...the starter is brilliant for captivating the students, particularly those who have been introduced to different ways for starting lessons, and different types, so…that's quite good for captivating them and then the plenary at the end of the lesson for a form of assessment, so you're not always relying on bookwork. (Head of Department)
>
> I think we all keep to that - you know the three-part lesson, er- going fairly well, we all use it, try now especially to use a good starter when we come in to get the kids settled as well, I found that more important because I'm moving around classrooms – I'm not based in one set classroom – so it's quite important to have something that I can quickly get set up and going, to get me settled..... .... But I think I'll say that the three-part lesson was something I'd seen with my primary experience with the training as well and…. it works quite nicely here, um… the main part I think that I have to think about is always coming back to the objectives for each lesson, and review my plan...(Newly Qualified Teacher)

However, some of the more established teachers recognised the value of this structure, but did not use it all of the time:

> I do the three part lessons, I mean ninety percent of my lessons will be three part lessons, and you know, I've got no problem with it. I mean it makes it easier because it formalises it more for me... ... I would think four times out of five you would, you're not going to see one tomorrow for yr11 for example because I'm doing, they're doing the experiment tomorrow and I don't want to disrupt that, so I'll just tack something on the end of that lesson.... ... I mean I actually came here six and a half years ago

> when there were Special Measures, and the three part lesson was introduced then, so I've always used it, I don't know anything else. (Experienced teacher)

It is clear from these responses that the three-part structure was a recognised and accepted part of lessons, and something to be used where possible. Of the other elements of the training provided by the National Strategy between 2001 and 2004, few ideas were as fully embedded in the consciousness of the teachers. The Head of Department could identify the implementation of group-work and the development of peer assessment as part of the Assessment for Learning initiative:

> That was a thing that we introduced from the Strategy, more group work, structured group work, so that we were able to give the students time to talk about it and share opinions, because obviously, as you know, in a class they won't always talk to the teacher. So when you put them in small groups and ask them to do a task, I think that's something we do, well, some classes do better than others. But I think that group work is quite positive for us. Same with peer assessment, because that comes along with the group work. They are more likely to comment on each other's work once they've swapped it over, mark it, give themselves a comment, and pass it back. It's quite good, they know what they're supposed to be looking for then. (Head of Department)

Once again, the experienced teacher had picked up the ideas, but with mixed motives:

> I use peer assessment quite a bit – partly because I'm allergic to .. I don't want to do my own marking a lot of the time but…I get the kids to look at each other's work, especially when it comes to marking tests, I think, some of them are gonna learn just as much from marking tests as from doing the work itself. (Experienced teacher)

The teachers recognised other changes in the style of their work in the classroom, for example referring to the increased use of ICT as a teaching tool. The expansion of this aspect, with the development of digital projectors, is an important feature that postdates the Strategy training. The use of prepared resources for presentation on the whiteboard was a lesson characteristic mentioned by all of the interviewees:

> In terms of ICT I actually bought myself a projector to use when I'm moving classrooms – and that made my life an awful lot easier, to use the new GCSE facilities, I just knew that would, I just needed that really, to support the new lessons, we have fantastic new science disks, with resources on to support the new GCSE, um and it was quite frustrating not being able to use them
>
> *Interviewer: That's really interesting. I mean, so you, you actually bought a digital projector?*
>
> I did, yes, I persuaded myself I could use it at home as well.
>
> (Newly Qualified Teacher)

This exchange reveals the need that the teacher felt to have this facility, their dedication to privately purchase an expensive item, and the fact that the school was unable to provide this teaching aid.

The teachers often referred to their wish to take students on visits to motivate them in science (see Hofstein, Maoz and Rishpon, 1990). The teachers mentioned the following types of trip:

- To science museums, to provide ‘awe and wonder’
- To places of work, to illustrate career opportunities
- To places of work, to show how science is used in practical settings
- To field centres, as part of the course of study
- To lectures, for interest and motivation

However, the teachers had come to accept that these activities would become less frequent in current circumstances, and the students also recognised that such opportunities were now rare occurrences.

(b) The Quality of Teaching and Learning

The quality of teaching depends on numerous factors, including the level of training, willingness to adapt, personal qualities, and the availability of resources. The Head of Department recognised that “...there was a slight barrier with our older, already structured teachers, who didn’t want to update their styles.”.

The training on new pedagogical techniques, as provided by the National Strategy, was typically delivered at central events attended by one representative from each school in the Local Authority. This model relied on the enthusiasm, energy and authority of the attendee to then ‘cascade’ this training to the rest of the department. The effectiveness of this process, which is reliant on human qualities and on allocations of time and resources, was typically low in the majority of schools.

> ... it depends on when you’ve got available time to have a meeting. If you’ve got a department meeting or learning team meeting coming up soon, you can pass that information on. But from a whole day, to summarise it quickly in 20, 25 minutes isn’t, isn’t very easy....(Head of Department)

Where training was provided ‘in-house’ to the whole department, the effective embedding of new ideas was greater. The Head of Department described her role since the Strategy training took place:

> ...we’d all been on Strategy training and our consultants had been in. We all knew what we were supposed to be doing, but the sharing of work, and the extra things, weren’t embedded as everyday tasks, so hopefully, I’ve managed to roll that out.... (Head of Department)

The newly qualified teacher relied on the Head of Department for advice on teaching techniques. She described the department team as being unified in their approach, and heavily influenced by each other. This created the conditions for a Community of Practice (Wenger, 1998) with the potential to be different from other departments (within and between schools) and also resistant to change:

> .. well, (HoD) was actually my mentor here, and I think she probably influenced me in terms of using, more of a variety of teaching skills…styles… not being afraid to try different activities. So I do tend to, to try and use a mixture, of everything - some boardwork, some ICT in terms of PowerPoints… um, and as much practical as we can, sort of fit in. So I – I don’t know how to actually describe it – it’s, it’s kind of a mixture…
>
> ... I think, certainly here, there are, um, perhaps staff who have their own ways of teaching, but I think, as a fairly unified trade we tend to use the current language – um, but I think you’ll probably find that everybody is covering all of the, the aspects of the Strategy, perhaps in their own way, depending on the classes that you have, um,

> so although perhaps we can actually identify which parts of the Strategy we're using in our lessons .. (Newly Qualified Teacher)

The experienced teacher also described being initially open to new ideas, but then developing a personal style. This illustrated that initial exposure to an idea during the early formative years of the teacher's career would often lead to the approach becoming embedded in the teaching repertoire, :

> You're very much like a sort of sponge, y'know, initially, and take up new ideas, then you sort of develop your own style and something that you're comfortable with, I know I have now, er, what is interesting and this is kinda very much reinforced by what you've said, what (HoD) has said and so on, is that the staff here are very adaptable and are open to new ideas, you've got new technology here and such like, so, so it sounds, er, as if we're not in a position where you 'can't teach old dogs new tricks' ... (Experienced teacher)

Despite the statement of this teacher to the contrary, he often revealed that he found it difficult to absorb new techniques and the philosophy behind them. He often used new ideas (eg. peer assessment) in order to save time.

However, this teacher was clearly weary of making an effort to engage with the classes, describing how he used to 'force' lessons and be concerned if the students were not working. He now used assessments to decide whether the students were learning:

> I used to get very concerned about kids not doing what I was asking but then you find out that well.. they knew it anyway and they're gone (unintelligible) because..they don't need to work hard on something, so I used to be very concerned about kids who appeared not to be doing their work and then you look more closely they are, so I'm less concerned now, um, so I rely on things like tests and assessments to see whether they're actually learning anything rather than just looking at their face and thinking "well they're not doing anything" or whatever, I'm less, less, sort of less formalised.... (Experienced teacher)

This, and other examples, illustrates a worrying scenario, where teachers are initially receptive to new ideas but become progressively fixed to a range of techniques that they are comfortable using, or else they can become less willing to engage with the needs of the students.

> ...it doesn't bother me any more if the if the kids aren't, um, doing exactly what I tell them to do ,and I used to get really concerned about but then you do that in your first couple of years, you want things done your way, all in your way, and after a while you get far more relaxed about it as long as the kids are learning from it, it really doesn't matter....(Experienced teacher)

(c) Support to raise the effectiveness of teaching

The teachers in the school, as in most schools, acted together to review the quality of their own teaching and to support each other socially and professionally. The Head of Department recognised the need to work as an integrated team to share resources and discuss the best ways to teach. The leadership of the department was critical to develop the atmosphere where success and failure in the classroom could be openly reviewed:

> Yeah, I think the major thing for this department is how close we are and how social the department is, so everyone was very keen to say "Oh, I tried this, it didn't work, so I'm going to try it this way" so therefore you weren't on your own trying to introduce a new change. It wasn't just down to department meetings to show your ideas, it was happening break, lunch, all the time, and because we are quite a close department you could nip in and watch someone's lesson and steal their ideas. And I think that

> was really good. So being a close department has really helped. (Head of Department)
>
> I think it's people who share ideas, and help, help each other, I think we work pretty well as a team. (Experienced teacher)
>
> Yeah I think that's a, um, that's one of the, the best things about the department because the things we do struggle with are things like resources, but as a team – we do, we get together frequently, you know, we don't tend to be left on our own, and we discuss lessons that we've had, any issues with students we know what's going on – and and general advice – as I say – if we're – we don't tend to divide it into Biology, Chemisty and Physics although, there's lots of..joking amongst the staff (laughs) in degrees of specialism but, um, certainly if we need help with a particular experiment to run, a practical, people are more than willing to help out and we do that within department meetings or just general lunchtime, breaktime meetings, so I think it's a really good department for that. I think that's one of , one of the reasons why it makes it quite enjoyable teaching here. (Newly Qualified Teacher)

The ability of the teachers to work as a team, sharing ideas and resources, is clearly a strong attraction to working in the school. However, there are issues with this arrangement. The teachers have observed a small number of lessons in other departments within the school, but not within their own department:

> I've not seen anybody teach in this department. (indecipherable) what I have seen, er, I've seen them talk to the children...... ... what I did was I had a meeting with (HoD) and a few of the senior management, and I said I was getting a bit worried my teaching was going a bit downhill - I wasn't really being, being very good technically so I've, I've actually gone to view other teachers, within the school. I went and saw three other teachers, and I found that viewing them has helped my teaching immeasurably, it's got my mind back in focus and back on track... (Young teacher)

The teachers rarely have opportunities to visit other schools, or to attend external training where they can network with other science teachers.

> ... the first few years to be honest I don't think I went on any course. I went to one or two across there *(indicates the nearby Teaching Centre)* and that was it, um, and I don't think I had much support at all for the first few years. I felt a bit lonely really, um, but apart from that, things have worked out well because I think I've sort of developed by myself really. (Experienced Teacher)

The result of this is a degree of insularity, where the teachers in the school develop ways of working that they fell comfortable with, and which may differ in small or major ways to the teaching and administrative methods used elsewhere.

> I think this, the science department, one criticism I'd make, is most people in the science department know nobody outside the science department, staffwise, very few of us do… I do. I mix with quite a lot of them, because I take the mickey out of 'em, most of them. But, er, there're several teachers in the science department don't mix with anybody. (Experienced teacher)
>
> ... there's a mix really for those who've had many years experience and those who've…it's fairly recent, um, but I think we generally probably all have the same strategy, in terms of teaching and learning, and getting a good result.
> (Newly Qualified Teacher)

In many respects, this department, and indeed the majority of subject departments in secondary schools, represented a classic 'Community of Practice' (Wenger, 1998). Relatively isolated, and responding to the local situation using their own interests and expertise, the teachers train and advise each other within the department. As a result, for example, this department has developed strategies to cope with the lack of resources for practical work. They selected those parts of the National Strategy that seemed readily applicable, and these entered common usage. Other elements of the Strategy were ignored or rapidly discarded.

(d) Barriers to further improvement of teaching

A number of issues presented difficulties for the department as it tried to implement the techniques proposed in the National Strategy training. These issues included difficulty in 'cascading' the ideas from the person who attended training to the rest of the department. One enthusiastic advocate could make little headway in a busy department where systems are already in place.

A second issue was the difficulty in firmly embedding changes within a teaching community where there is a temptation to return to a default position which is economical in time and effort. For example, several teachers referred to lack of time for lesson planning, and admitted that good methods were not used in lessons because of lack of planning time:

> I think my major problem is finding the time to plan them properly. I think to improve my lessons I'd like to do more planning, because I know that every time I do put effort into planning I come up with a little bit more interesting lessons that I would do, if I don't spend so much time. (Experienced teacher)

A critical issue, raised by several of the teachers, was the lack of finance, and hence lack of resources:

> I think finance really slowed us down, in this department, because you need some things to help you out, to make your... to do different parts of the lesson, like data-logging equipment, whiteboards to show clips of films and moving-around tasks. (Head of Department)

> I think - the most frustrating thing is the lack of resources – and, we do tend to – we have to be fairly creative sometimes in what we do – but, I think practically, we are we are very short of – we cannot carry out some practical work because of a lack of resources. (Newly Qualified Teacher)

The NQT also described the frustration of recently attending a training day at a local selective school to learn about how to use various practical techniques in teaching, only to realise that she couldn't use the methods because her school lacked essential equipment. This same teacher bought herself a digital projector for use in school, as one could not be provided by the department.

(e) Student attitudes and the factors that affect engagement in lessons

The teachers were able to identify the key elements of lessons that created good engagement, and the most significant was hands-on practical work, as also identified by the students themselves. The teachers could see how this helped the learning process:

> I do believe that certainly, well I think with all abilities - getting a chance to be hands-on does help them understand, as well as, y'know, well you can write things down but to do it hands-on as well, just…helps it stay..in mind…and that's the reason I did science at school I mean.. I did all sciences because I loved doing practical work. (Newly Qualified Teacher)

The link between practical work and engagement in the lesson was clearly made, but the teachers were less clear about other factors. The need for science in many forms of employment was understood by the students, but teachers felt that factors within the subject were more important, for example whether it was presented in an interesting way. In other words, the career aspirations of students were not significant as a factor in day-to-day enjoyment:

> Well some of them would say science is boring, and some would say, they'll never need science, for whatever job they'll do. (Newly Qualified Teacher)

The students appear to have no expectation that they could gain employment in a scientific field or related work. In some cases, the teachers blame the low aspirations on the students, whereas the issue may stem from low aspirations in the whole community, including the teachers themselves:

> I think very variable, you've got kids who can't stand the subject and kids who love the subject, and kids who understand the importance of science and kids who don't understand the importance....I think there is the whole spectrum, I think the kids in this area have low expectations, academically they have low expectations, they don't.. a lot of them don't think about school as being important, to a lot of them it's a social event rather than a sort of work based thing. I mean a lot come to school without a pen and that sort of thing, I think that, um, in this area parents don't have high expectations for their kids, kids don't know how to work, they are discouraged from doing things like reading, writing, because they have their homes they come from, it's very, very low priority... (Experienced teacher)

This teacher identified what he described as 'aspirational deprivation', where the students do not aspire to anything. He saw the pressures as being external to the school:

> I think peer group pressure in this sort of environment is far, far, far more important: it's peer group pressure, it's family expectation, um and it is the sort of culture they're immersed in, the sort of Hollywood Bang-Bang culture... (Experienced teacher)

The teacher could see the low priority given to science in the lives of the students, but he did not link this to the quality of their classroom experience:

> What always amazes me is the kids always want the latest gadgets, they always want the latest technology and they don't appreciate the science that's gone into them, and yet they still attach a relatively low importance to Science. (Experienced teacher)

Each teacher interviewed could identify aspects in the current Key Stage 3 and GCSE courses that were both attractive and were difficult for the students. The new concept of How Science Works, and the emphasis on relevant science that related to everyday experience, both opened lessons to greater engagement with the interests of the students. However, there was a universal feeling that the new courses had failed to live up to expectations. The Head of Department recognised the previous problems:

> What was previously happening was in Key Stage 3 they were very switched on to science, they were very keen, and when you got into Year 10 and 11 it just died down. With the new scheme coming out there's a lot more relevance to everyday science , a lot more thinking skills being involved, so I think now there's an improvement just coming in, but I think previously there wasn't so much because I think it just dropped [motions with hands] after Year 9. (Head of Department)

Interestingly, this change between Key Stage 3 and Key Stage 4 was identified by Abrahams and Saglam (2010), and was linked to the different purpose of the practical work carried out by students of different ages. Teachers used these activities in Key Stage 3 “...to arouse and maintain interest in the subject...” (ibid., p.761), which had been the purpose of practical work since the study by Kerr in 1963. In contrast, in 2008, the purpose of practical work in Key Stage 4 had recently become linked to preparation for assessment activities (Abrahams and Saglam, 2010, p.763), and this was less effective in capturing the imagination of the students.

Yet when it came to analysing the causes of the lack of engagement in lessons, the Head of Department unintentionally revealed the most significant factor after initially concentrating on external issues:

> I think it has to be the wider community, simply because some students like science and some don’t, and it doesn’t matter when they are friends or not. Employment prospects, it would be lovely to think that they are thinking that far ahead. Some come up with “I want to be a doctor” or something, but they don’t think that far ahead. I think if they have an environment around them where they are watching nature programmes or programmes that question their thinking, maybe parents or adults at home are asking them to…their opinions….. I think anything where there’s…they have access to reading, looking at papers, and…then they’re the kind of students that go and question and enjoy science, but as we know our intake aren’t those kind of students here. We don’t have many that would be sitting at home reading the newspaper with their family (No) and discussing Global Warming over the dinner table. I think, sometimes its just down to a matter of curiosity, those students who are constantly wanting to learn something, if they are coming into Year 7, *something grasps them like an enthusiastic teacher; unfortunately Year 7 and 8 students like a subject according to who they’ve got, I think....* (Head of Department) *(researcher’s italics)*

The Head of Department thus identifies in turn: the local community, employment opportunities, exposure to media influences, the family and literature as being factors in shaping the attitudes of students towards science. And yet, at the end, she identifies innate curiosity and the overwhelming shaping influence of the particular teacher that the student has in the classroom. Thus, the role of the teacher in creating an atmosphere of interest and activity is seen as fundamental to developing the engagement of the students. This was confirmed, for example, by Beauchamp and Parkinson (2008), where ‘a teacher factor’ proved more significant than other characteristics in lessons.

The school struggles to encourage students to continue with their science studies post-16, into the Sixth Form to study A levels. Only a small number take their science beyond the compulsory GCSE level, and the Head of Department had hoped that the new GCSE might encourage greater participation in the future, to meet the DCSF target for more science uptake at university (National Indicator 85). However, the students do not appear to focus on employment or on university until they reach that stage of their lives. In other words, the students do not make academic choices based on future options:

> I’ve been thinking about this, like, for mad, because we really struggle to get students on our science courses. I think its very much down to where they want to go, making sure of, they are aware that science A levels or Key Stage 5 qualifications open a few doors for them. They need to realise where they could go with it, so trying to publicise more, you know, job prospects, because that’s something that could captivate them, but some students don’t even think about potential job prospects until it comes to leaving school. (Head of Department)

And ultimately, the widely perceived difficulty of science in comparison with some other subjects is a deciding factor for many students:

> I think it’s also a little bit of laziness, as well, they’ve got through their GCSE’s and they think science A level is going to be much harder and they are scared by the amount of work and they don’t see that the reward is at the end, and they can go and do a BTEC in Business or something, and get told they are going to get 4 A levels for it, and that’s a lot easier, and when they are comparing the two subjects together, hard work and get one A level, or sitting on the computer and doing something quite simple, and get 4 A levels, you know, any student can see one route is easier, and if they haven’t got a point at the end they are aiming towards, like potentially going to do a science degree, then there’s no point doing science, in their eyes. (Head of Department)

Thus it is, in the views of the teachers, that science in this school is handicapped by a range of factors, both internal and external. Some of these factors can be influenced by the teachers, but others cannot. (see Table 20)

	Internal to the school	External to the school
Potentially influenced by the teachers in the department	Quality of teaching and learning in the classroom Internal support for teachers within the department Raising awareness on opportunities in employment and at university Science clubs and visits	Parental aspirations for the future of students in scientific employment Parental attitudes towards science Training provision and professional development for teachers
Not readily open to influence by the teachers in the department	Level of funding for science Recruitment of suitably skilled and dynamic teachers Attitudes of students to science on entry to the school Ability of students Relative attractiveness of other subjects in school	Perception of relative difficulty of science GCSE and A level courses compared to other subjects Science-based employment opportunities in the local area Portrayal of science in the media, including television and cinema Home environment of students, and exposure to science-related resources

Table 20: Perceived barriers to science education, and the ability of the teachers to address the issues

4.3 Lesson Observations

The purpose of the lesson observations was to provide a backdrop to the comments made by the students and the teachers during the interviews. This would provide a context, but may not allow for true triangulation because the observations are themselves open to interpretation and bias. The essentially subjective nature of the observations would, however, permit questions to be asked where there is a gross disparity between the observations and statements made during interviews.

The observations made use of the professional experience of the researcher as a qualified Ofsted inspector and a senior Local Authority adviser/inspector. This experience made it possible to disentangle the many simultaneous events taking place in the lesson, and identify the key events. However, the possibility of unintentional bias cannot be ignored, since prior experience makes it likely that the observer will concentrate on events of likely significance:

> …the last thing a naturalistic observer should want to do is to become a fully experienced member of the group who are being studied, because fully experienced members are the kinds of people who take for granted the things which researchers ought to regard as puzzling. (Gomm, 2004, p.221)

A similar concern during observations is the 'Hawthorne Effect' (Landsberger, 1958) where the teacher and / or the students may not behave normally during the lesson, but instead may behave according to external expectations. The teachers were aware in advance of the observations, and had planned the lessons more thoroughly that would be typical. This prior notice could not be avoided because of the professional agreement with the school and with the teachers themselves. Ethically it would not have been possible to observe lessons without notice. The teachers were assured of the anonymity of the research, but nevertheless they wished to present themselves in the best light.

The students were not aware in advance that the lesson would be observed, and their responses were possibly more natural. However, there still remains the possibility that the students would behave differently – better or worse – when an observer is present in the room.

With these caveats, the lesson observations were conducted discreetly and every effort was made to become 'part of the furniture' at the back of the room.

4.3.1 Method of observation

In total, eleven lessons were observed during one week. The lessons seen were dictated by timetable restrictions and the agreements of individual teachers, but eventually all members of the teaching staff were seen, covering a range of ability groups in the three study year-groups. Four lessons were seen with Y7, five with Y9 and two with Y11.

The observation process involved being present in the room before the class arrived, and sitting at the back of the room for most of the time. Occasional walks around the room allowed interaction with students to explore their understanding of the topic, to look in exercise books, and to discuss their feelings about science in general. Notes of observations were recorded on standard Ofsted Evidence Forms, and the aspects covered included the structure of the lesson, student responses, and teaching methods employed.

Following the observations, the eleven lessons were reviewed for themes, and these were grouped to identify significant features on the overall lesson approaches in the school.

4.3.2 Analysis of observations

It was evident that in some cases that the teacher chose to make a particular point for the benefit of the observer. For example, one began the lesson with the following statement to the class:

> "OK, so it's more about velocity. As you can see, we are <u>supposed</u> to be doing a practical. Unfortunately, we can't as we don't have a data-logger, so it's theory only..."

The use of a recognisable 'Three-part Lesson' structure was a feature that was visible in just four of the eleven lessons. This is despite the teachers recognising during interviews the importance of this lesson structure, and stating that it would be seen in all but a few lessons.

Students were actively engaged in eight lessons, with good responses and close attention to the activities in which they were engaged. The indicators of active attention included focus on the teacher / whiteboard, inter-student discussions on the topic (as opposed to off-task talking) and asking questions of the teacher. The lessons with active engagement also allowed the students to make progress, and the evidence for this was seen in learning of new ideas.

Five of the eleven lessons had practical investigative work as the main component of the lesson. Four of these five lessons were included in those where good progress was made and the students were engaged in the lesson. In just one practical lesson were the students unresponsive, and these students demonstrated poor behaviour and other signs of disengagement. Thus, there was a link between practical work and good response in lessons, but the link was neither absolute, nor was it necessarily causal – it may be that teachers with a good relationship with their class are more inclined to allow their students to take part in investigative activities.

In seven of the eleven lessons the teacher dominated the talking, with some lessons being almost devoid of independent student talk. In the same seven lessons, the style of questioning was 'closed', with only simple factual responses being required. In contrast, the lessons where students were able to discuss issues themselves – rather than have the teacher lead the discussion – the questioning was often 'open', with longer and explanatory answers being expected. This showed a clear link between a teacher-led approach and closed questioning styles – both of these styles tending to close off any student discussion.

In contrast, the teacher-led (as opposed to student-led) approach did not correlate to the use of practical or group work teaching styles. Unexpectedly, some teacher-led lessons involved group work where the students followed heavily directed tasks, or practical work where the students followed instructions in a mechanical style. Thus, the use of practical work and group work, both approaches promoted by the National Strategy, were applied (or not) independently of the choice between didactic or student-led teaching styles.

Feedback to students, whether immediate as verbal responses in lessons or more formalised as written marking of work, was not well developed in the lessons seen. The teachers did not make overt use of praise or encouragement, and marking in exercise books was infrequent in all but one case. Thus, the students in these lessons did not have their scientific thinking recognised and did not have guidance for further improvement. While the lack of praise in the lesson could, possibly, be an artefact of the observation process or the nature of the lesson, it remained a distinct feature of these lessons.

The classes were 'set' by ability in years 7 and 11. The format of the lessons, as seen in the observations, was not affected by the relative ability of the class. In other words, the teachers did not use noticeably different styles with groups of markedly different academic ability. The balance of evidence supports streaming in science (Ireson and Hallam, 2001, p.108), but the expectation would be for teachers to modify their teaching to suit the group, and to set work at an appropriate level for the students. As Ireson and Hallam noted:

> When pupils are grouped by ability, teachers seem to underestimate the differences between them and tend to abandon the differentiated and varied methods they use with mixed ability classes. (p.127)

The lesson observations in this study support this proposition, and there was little evidence of differentiation by ability or recognition of individual needs. The differences between lessons therefore hinged on the quality of response from the students. For example, when not engaged in the lesson, the more-able students remained essentially passive and compliant. In the lower ability groups, lack of interest in the lesson resulted in off-task talking and low-level disruption in the class.

4.3.3 Discussion of the Observations in the context of the National Strategy

The National Strategy introduced an emphasis on particular areas of student experience in lessons, including engagement, progression and high expectations. These were further reinforced in the Key Messages file sent to all schools (see DfES, 2003). The expectations for lesson experiences, as articulated in this document, were not well developed in the lessons seen in this study. The expectations included a structured approach, clear objectives, manageable differentiation and effective questioning. The students did not experience these aspects in all of their lessons, and may actually experience them rarely, if at all.

The teachers, when interviewed, recognised the value of the three-part lesson structure, a key part of the Strategy training. They described that they wanted to use this structure, and considered that they widely used this format in, perhaps, 80% of lessons. This was not the picture seen in the lesson observations, the student interviews and the questionnaires, where a frequency under half was indicated. In other words, the teachers thought that they used this structure twice as often as they appeared to do so.

To this extent, the aims of the National Strategy were only partly successful in the lessons seen, and the impact of the Strategy in terms of the regular experience of students had not been great.

In general terms, the lessons observed were closer in style and structure to the descriptions given by the students (during interviews and in questionnaire responses) and in many respects did not correspond to the statements of the teachers. There could be many reasons for this, but significantly it illustrated that the teachers did not conduct lessons in the way that they had themselves described, and they often made even less use of Strategy methods than they had suggested.

Chapter 5 Discussion

The aim of this research has been to explore the impact of the National Strategy for Science, in its approach to change teaching methodologies and through this to improve student attitudes towards science. A range of methods were used to investigate the issues, with the intention that a broad-based research would provide validity to claims and provide a clear picture to this case-study investigation. Induction, i.e. inference based on many observations, may be a myth (Popper, 1969, in Hollis 1994), but the research approaches did not contradict their outcomes, thus suggesting a degree of coherence to the analysis of issues, if not true triangulation.

In practice, no research method is entirely qualitative or quantitative (Yin, 1994), and the mixed approach can prove valuable in viewing an issue from different perspectives. However, the data used in this study were examined qualitatively, without straying into areas of full quantitative analysis, since this would have been inappropriate. To enhance the richness of the research, and the validity of the results, a combination of qualitative approaches was used in this study. In addition, data from many sources can be mutually supportive, and provide new ideas and fresh insights (Miles and Huberman, 1994). Use of multiple sources of evidence is rated more highly in terms of their overall quality than those that rely only on single sources of information (Yin, 1994).

The case study context, Ashbourne School, was receptive to changes throughout the period of the National Strategy, and was fully supported by a team of consultants based in a nearby Teaching Centre. The availability of training and in-house support made it easy for teachers in this school to access the messages and resources of the Strategy. Also during this time, the school was slowly transforming, with improving student attitudes and sharper leadership at all levels. Against this backdrop, the science department maintained a traditional teaching approach for much of the period, with unadventurous leadership and challenging classes. More recently, a new leader has injected greater energy into the department, with greater teamwork between teachers, and more acceptance of new teaching approaches.

5.1 The impact of the National Strategy for science on teaching methods

The results of the research will give little comfort for policy makers if the picture in this case study is replicated across a wide number of schools. In essence, the National Strategy for Science appears to have had little long-lasting impact beyond the initial progress made in the first few years, and much of that initial impact has been diluted over time. This is demonstrated by the fact that few of the ideas and techniques of the Strategy were mentioned by the teachers, or used during their lessons. In contrast, interviews in 2004 revealed that the interviewees each identified around fifteen different components or techniques linked to the Strategy.

Embedded change

For any initiative or action to be ‘embedded’, the change must become a natural part of normal routines, such that there is an expectation to see the changed behaviour as a part of the normal work practice. An example of embedded activity in many schools would be the setting of lesson objectives, use of the QCA scheme of work, or assessment using National Curriculum levels. Although an embedded activity may not be present in every lesson, it would be a generally accepted expectation.

Various factors may be required for an initiative to become embedded. These factors include:

- Accepted need for change by those involved
- Simplicity and practicality of message

- Adequate training to all participants
- Funding and resourcing to support the change
- Return on investment (for example: improved results, reduced workload)
- Ongoing commitment and prioritisation
- Monitoring of use
- Review and consolidation

If any of these factors is absent, then the change may be introduced partially, or without enthusiasm, and may wither as participants revert to prior practice.

Where a change, such as the approach advocated by the National Strategy for Science, does not appear to be embedded, then it must be asked whether subtle change has happened, or whether indeed there has been no impact at all. Further, if there does not appear to be an adoption of the change, then why is this so?

In this context, have the changes in pedagogy not been widely and fully adopted, or have they been assimilated into lesson processes in such a way that they are not individually identifiable? For example, have plenary sessions failed to form a recognisable end to the lesson, but instead the process of review and consolidation takes place in other forms? The evidence from the lesson observations and from interviews would not indicate that the ideas, concepts and processes of the Strategy have been adopted to any significant extent.

Where the teaching does not demonstrate clear use of National Strategy ideas, it is necessary to explore whether the teacher made a strategic or a pragmatic decision not to employ the approaches, or indeed whether the teacher was unaware of the range of ideas put forward during the National Strategy training. The interviews with teachers demonstrated that they were aware of some of the main outcomes of the training (including the three-part lesson) and that they knew of the value of this approach. Their decision not to use this lesson format in most cases was therefore not a strategic decision, but was apparently a pragmatic response, possibly to the need to prepare lessons on a daily basis, and the need to minimise preparation time. The decision did not appear to be conscious, since several teachers thought that their lessons would contain elements of the National Strategy guidance, but instead there was an unconscious filtering of particular components.

Given that little had changed since the introduction of the Strategy, it is important to consider whether the teachers (and the system overall) are cynical of change – particularly when driven externally – in the belief that such change is generally ineffective. Certainly, the barrage of initiatives in the last decade has involved reorganisation and a considerable input of time, resource and effort, without profound change in outcomes for students. A cynical realism could be expected.

Equally, on an individual or group level, teachers may display a resistance to change, producing inertia within the system. This innate resistance is common (Ellsworth, 2000) and may be a natural human reaction, rather than caused by a particular factor.

Embedding the National Strategy for Science

The key identifiable barriers to the fully embedded Strategy were (a) the failure of the cascade model for providing training, and (b) the lack of continuity in promoting the aims of the Strategy approach.

The 'Cascade' model for training teachers relied on one representative from the science department attending a centralised training session, and then returning to their school as an advocate able to pass this knowledge to all others in the teaching team. Even assuming that all schools sent representatives to the session, the expectation that the teachers would be sufficiently skilled, motivated and empowered that they could influence the work of their colleagues was highly optimistic. The issue was recognised in the 2004 Phase One study:

> It came across informally; it came back probably over coffee, or something. It would have been better to have had a longer period to cascade more effectively...There have been, you know, handouts circulated to other members of staff, I've written one on assessment and we've changed our assessment policy in view of that, and I did feed that back in some detail. So its been variable really, some people have given detailed feedback, others just one or two points, like the one who went on 'investigations', we had the post-it type sheets, which were quite handy, but not a lot else. Whereas the one on assessment I attended, there was a bullet by bullet, point by point *(report)* covering some of the things like 'no hands up', and no grades on work, and so on, there was quite a difference.....
>
> (Head of Department, Phase One study, 2004)

This Head of Department, in 2004, described different experiences and different styles of feedback to the rest of the department team. Significantly, in just this brief paragraph, he mentioned several of the key 'messages' from the Strategy that went unmentioned in the extensive 2008 interviews.

The comments made during the 2008 research, particularly during the teacher interviews, demonstrated that in this school at least, the new ideas remained with the teacher who attended the training session – and even they did not feel ownership or commitment towards the concepts that had been demonstrated. In other words, the single training session failed to profoundly influence the attendee, let alone the others in the department.

The second problem stemmed from the single-shot approach to influencing teacher behaviour. The numerous training events, concentrating on, for example, misconceptions, the teaching of energy, or earth sciences, were delivered once only, with no planned reinforcement of the ideas at a later date. As a result, the materials were sent into schools, with the expectation that these would become embedded in classroom routines. Almost invariably, the white Strategy folders languished on shelves, ignored in practice. This issue was identified in both of the initial interviews in 2004, where the Heads of Department were keen proponents of the Strategy, but recognised that only a minority of ideas were being implemented. Given that the Strategy training was current in 2004, it is perhaps little wonder that in 2008, after no reinforcement, the situation was worse.

The single-shot approach to bringing about profound change within the profession took no account of the turn-over of staff, allied with staff shortages at the time, with the result that science departments were highly unstable and concentrated on day-to-day issues rather than developmental change. The lack of repetition of training, allied to a reluctance to change, when added to the barrage of other initiatives, can be seen as the principal factors in preventing significant change in the teaching of science.

The structure of the majority of schools in Britain, of which this case-study school is typical, creates a natural situation where subject departments tend to form communities of practice in isolation from other departments within the school, and in isolation from other similar departments in neighbouring schools. As a result, the department teams are often social groups, mutually supportive and sharing techniques and resources. The teachers in the case study were well aware that they had little opportunity to meet with other teachers outside the department and share ideas. The situation is likely to be worsened in the future by restrictions on covering for absent colleagues (thus reducing opportunities to attend training), by shortage of funding, and by the trend for local schools to support each other.

Each of these changes will limit the exposure of teachers to others from a wider sphere, and will thus tend towards science teachers becoming less aware of new pedagogy.

In this context, the introduction of the methods advocated by the National Strategy has been slow, irregular and patchy, with some teachers in some schools embracing the new ideas while others fail to do so. The reasons for this failure appear to reflect the school's ethos and context, as well as the personalities and politics within the science department.

> "This finding is of particular significance for policy initiatives which seek to apply uniform standards of professional practice across schools, or to alter teachers' work to uniform prescriptions." (Donnelly, 2000, p.272)

The lack of continuous pressure for change, applied by concentrating on a few key messages and repeating these until embedded in teaching routines, had thus been a serious weakness in the introduction and consolidation of the Strategy for Science. This issue was identified in the 2004 phase of the study:

I think that the whole Strategy was over-ambitious. I mean, if you think about eight talks, you know, with twelve, fifteen bullet points in each, a hundred points…it was way too ambitious in the amount of material they expected people to cover. It would have been better if they'd said "These are the three points to take away from this. Please now, try and implement these three." It didn't seem to have been thought through, and it seemed to be almost a shotgun approach rather than a bullet approach, you know, here are ten, twelve points to feed back, whereas it would have been much better to have say two or three, and by the way you may want to think about the others. I think there was too much information in each element.

(Head of Department, Phase One study, 2004)

With the benefit of hindsight, the situation became more serious, with teachers faced with an endless stream of new initiatives, each worthy, but distracting attention from what went before (see section 1.2).

5.2 The impact of the National Strategy for science on student attitudes

The students and the teachers were in agreement that the student attitudes to science were affected by many factors, but in general, attitudes were not positive. They recognised the following principal factors:

- Low interest in science, stemming from peer pressure and cultural factors.
- Low expectation of gaining a career in a scientific field
- Low scientific aspirations, stemming from parental and teacher comments
- Low frequency investigative practical work

In addition, the students identified poor quality teaching, high staff turnover, and the difficulty of the subject as being issues. The teachers identified lack of resources, examination pressure, and the volume of subject material within the National Curriculum. It is highly significant, though not entirely surprising, that the teachers identified factors other than their own teaching, thus removing themselves from the equation. This view is not supported by recent research evidence, which identifies the individual teacher and not resourcing as central to making science interesting (see Beauchamp and Parkinson, 2008, for example).

The student perception of their science in primary school was ambivalent, with as many recording positive as negative memories. In general, their recollection was vague and often they did not recognise the science components within their days.

In contrast, almost all students began secondary science with high hopes, only to have this enthusiasm dashed as they encountered, in their belief, disappointing work, lack of practical work, and poor teaching. This contributed to falling confidence, and growing concerns about their performance. As confidence fell, concerns about examinations rose, and students felt a distance from the subject.

The popularity of science has remained around the median position amongst school subjects taken, and this applies to all age-groups sampled, and was equally true in 2004. The key attraction of science, the hands-on practical investigation, is still an area where students of all ages would like to see more emphasis, and this is particularly true in the older groups, where the pressure of examinations has encouraged the teachers to reduce practical work in favour of textbook studies. The frequency of practical work appears reduced since 2004, despite changes in the syllabus to encourage investigation.

The student association of enjoyment with practical work in science was remarkable. It was the most striking aspect that was linked with the move to secondary school, with their expectations built on what they had been told by parents, peers, and older students. Their expectations were often unrealistic, hoping for exciting explosions on a frequent basis.

The students did not appear strongly motivated by the content of the courses, in either Key Stage 3 or Key Stage 4. Given the freedom in the delivery of Key Stage 3, and the newly revised 2006 GCSE syllabuses in Key Stage 4, it is clearly a disappointment that the students did not show more enthusiasm for their science courses. Despite attempts to make the courses relevant and less content-laden (see Wellcome, 2001), the students still failed to relate science in the classroom to their current experiences and future career aims. Indeed, their perceptions of science and scientists were broadly negative, despite the efforts of the Strategy to change this.

Increased freedom and a possible reorganisation in the primary curriculum from 2011[1] (http://curriculum.qcda.gov.uk/new-primary-curriculum/) may reduce some of the decline in interest that begins in late primary years and continues through into secondary schools. In particular, the emphasis on applied science may have some benefit. However, the issue of student attitudes appears to be system-wide and characteristic of more economically developed countries (MEDCs) rather than a unique feature in Britain. This suggests that solutions based on the primary and secondary curriculum alone are unlikely to provide a solution. Student attitudes appear linked to wider society and factors beyond the school. However, within a school, the quality of teaching and the characteristic of the teacher are of paramount importance.

Thus, any profound change in student attitudes requires a widespread change in the values that society and the local community place on the role and status of scientists, alongside changes in the teaching repertoire employed in schools. Of lesser importance are the nature of qualifications and the content of the courses. The National Strategy for Science set out to change the way that science was taught. Evidence suggests that this was undoubtedly the correct pathway, but without an allied change in the views of society, and without the necessary investment to embed the new approaches, the Strategy has not been widely successful.

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[1] Following a change of Government in 2010, this may not take place

Chapter 6 Conclusions

In this final chapter, the outcomes are discussed in terms of the research questions, and in terms of the wider applicability of the research. The outcomes indicate clear and highly significant issues in the case study school, which appear to be widely generalisable. Furthermore, the conclusions demonstrate a need to reconsider the ways in which initiatives are introduced to schools in Britain.

The research questions, as described in Chapter 1, are:

Research Question 1:
To what extent have the teaching methodologies promoted by the National Strategy become embedded in the everyday practice of teachers?

Research Question 2:
To what extent do students relate positively to these methods?

Research Question 3:
Have student attitudes to science become more positive since the introduction of the Strategy?

Research Question 4:
To what extent can any change be attributed to the National Strategy approaches?

These research questions sought to explore the effectiveness of the National Strategy for Science, by exploring the long-term impact of the Strategy. The four key principles underpinning the strategy were:

- Expectations: establishing high expectations for all pupils and setting challenging targets for them to achieve;
- Progression: strengthening the transition from Key Stage 2 to Key Stage 3 and ensuring progression in teaching and learning across Key Stage 3;
- Engagement: promoting approaches to teaching and learning that engage and motivate pupils and demand their active participation;
- Transformation: strengthening teaching and learning through a programme of professional development and practical support.

(source: DCSF: http://www.standards.dcsf.gov.uk/studysupport/impact/ks3/)

The sources of evidence for the research, first shown in Figure 3, are repeated below.

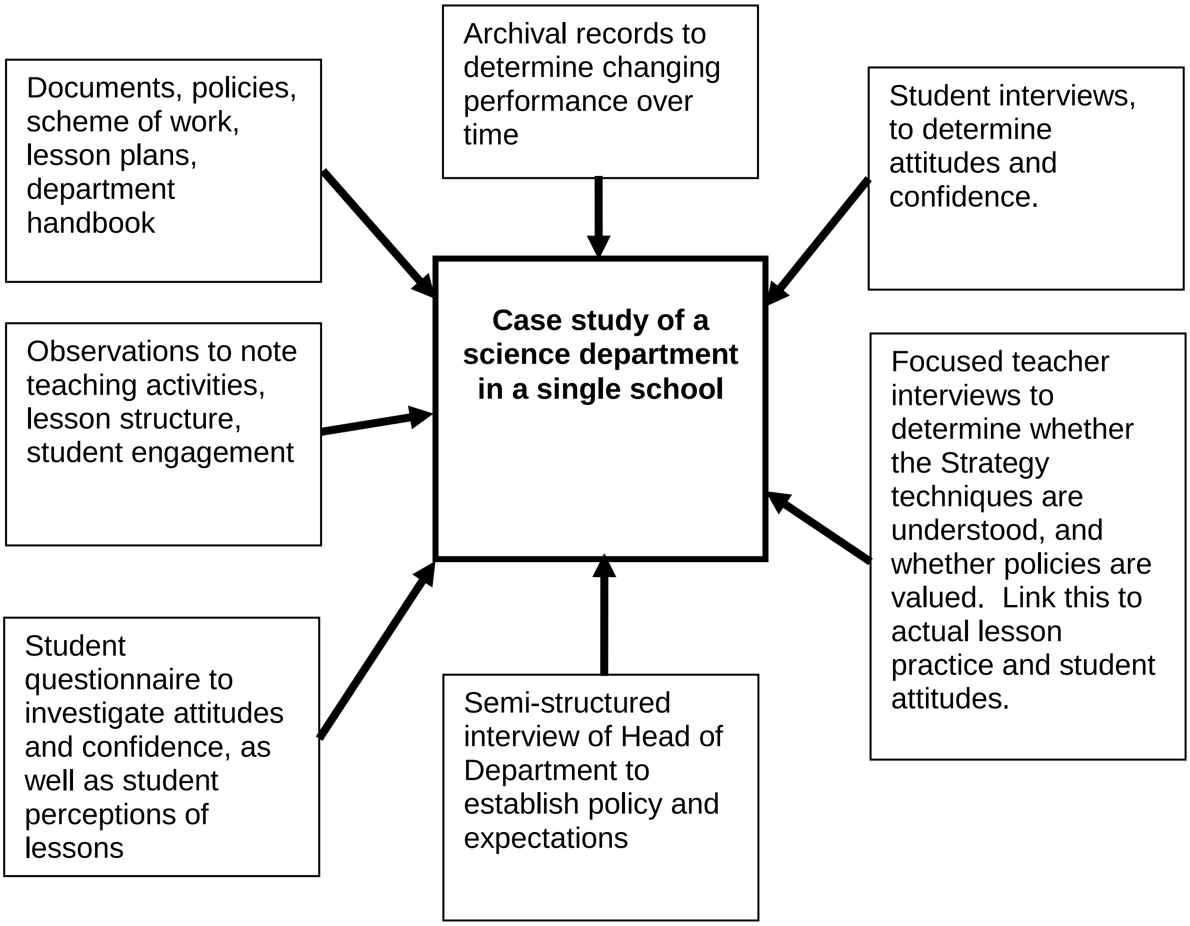

Figure 11: Evidence used in the Case Study. Adapted from: Convergence of Multiple Sources of Evidence (single study) in Yin (1994)

6.1 Key outcomes

Research Question 1:
To what extent have the teaching methodologies promoted by the National Strategy become embedded in the everyday practice of teachers?

The various sources of evidence, which in this case included direct observation, interviews of teachers and students, inspection of lesson plans and the key scheme of work, and comments from the questionnaire survey, all confirmed that the specific pedagogical principles promoted by the National Strategy had made little inroad into the day-to-day lesson delivery in the school. In most cases, teachers were able to recall some of the key aspects of the Strategy ideas, and they often stated that their lessons featured these aspects. However, observed lessons did not universally demonstrate that the Strategy structures and ideas were in place, and the students stated that these features were rarely employed. Thus, the ‘three-part lesson’, group work, targeted questioning, student engagement and similar components of the Strategy were not well developed, and were not embedded in lesson routines.

Research Question 2:
To what extent do students relate positively to these methods?

The responses from students, as indicated in both interviews and in the questionnaire, showed that the students of all age groups clearly understood the National Strategy approaches. For example, they described the aims of the ‘starter’ activity and recognised where this occurred. However, they did not see this as a regular part of their science lessons, although they did encounter these activities in other subjects. The students enjoyed the approaches, and regretted that in their science lessons the approaches were not common. The evidence thus does support that the students related to the methods, where they were encountered, but this did not happen regularly in science lessons.

The improvement in science results in the case study school during the period of the Strategy (see Figure 12, Appendix 1) could not be reliably attributed to the Strategy approaches. However, it is evident that a significant change did take place, leading to improved outcomes for the students. This may suggest that there had been a greater awareness of new pedagogy in the earlier days of the Strategy (and this is supported by the 2004 questionnaire data), but that the use of these approaches had become less prevalent by the later stages, as shown by the 2008 results. The new pedagogy may thus have caused improvements in teaching that are less obvious than the mere use of the three-part lesson, for example, and the more recognisable aspects of the Strategy – including the assessment and the teaching sequence framework – were no longer in use by the final years of the Strategy. Thus, the students may have benefitted from the methods, but only indirectly.

Research Question 3:
Have student attitudes to science become more positive since the introduction of the Strategy?

The evidence suggests that student attitudes have not become more positive, and instead have become quite negative towards some aspects of science both within school and within wider society. This reflects the broader changes in society, and is not unique to Ashbourne School. In the eyes on young people, the scientist has long occupied a near mystical status in popular culture, but increasingly the role of scientists has shifted from being mysterious but certainly beneficial experts, towards being open to possible criticism and challenge. Thus, the students challenged the role of scientists in ‘creating’ global warming and pollution, and criticised them for not preventing disasters and diseases. These attitudes mirror the sentiments expressed in wider society, and have influenced the students to a greater extent than any changes in lesson content or style.

Research Question 4:
To what extent can any change be attributed to the National Strategy approaches?

The changes in student attitudes reflect views held in the wider social groups outside the classroom, and are clearly strongly influenced by the media and adult groups. The students referred to conversations with their families and to television programmes. Their attitudes share much with the attitudes of students across the economically developed world (Sjøberg, and Schreiner, 2005: i), and thus their views are not significantly shaped by the National Strategy.

This point demonstrated the importance of ongoing research into student attitudes, and indicates with hindsight that, in this case study school at least, it would have been more effective to change student attitudes by other means, rather than through changes in the science classroom. Indeed, research suggests that a wholesale shift in the wider adult society may be the only effective means to change student attitudes.

6.2 Overall perspective

This study set out to explore, in one very typical school, the impact of the National Strategy for Science on the teaching approaches and the attitudes of students. These two aspects are interwoven and interrelated, but form the essential focus of the Strategy.

The study has answered these research questions, but in so doing has messages that will prove challenging for policy makers in education. Essentially, the findings are that:

(a) Student attitudes towards science have not changed significantly, and may indeed be worse, since the introduction of the National Strategy. Despite considerable effort and expense, including the introduction of more student-centred GCSE syllabi in 2006, the expressed attitudes of students remain generally negative.

(b) Teaching methods have not changed significantly since the introduction of National Strategy ideas, and teachers have broadly reverted to styles of teaching where they feel comfortable and where workload can be minimised. In many cases, teachers cannot recall the particular messages from the main training (five years previously).

(c) Student attitudes towards science are more markedly influenced by wider society than they are by what takes place in the classroom. This has been demonstrated by the ROSE research, and by the comments made by the students themselves. As a result, the aim of the National Strategy to engage students in science could be seen as misdirected. It may have been better to invest in changing public perception through campaigns in the media.

The most important conclusion from this study is that in this type of school, typical of many institutions, educational change and reform needs time and pressure to make it embed into the daily routines of the teaching workforce. Constant change and the introduction of imposed initiatives does not create a reflective and evolving system, and certainly does not serve to keep the profession ‘on its toes’ and able to adapt to changing needs.

Instead, the layering of one initiative on top of another, with little time to reflect, evaluate and absorb, created a sense of exhaustion and unwillingness to participate, ultimately leading to a subversive resistance to change.

These conclusions were supported by the senior leaders in Ashbourne School, as shown in the following comment:

> *The drive from government to respond to workplace demand has led to a focus on science in schools which is not always equitable in time allocation as the other areas of the curriculum which could equally be said to be ‘in demand’ by the workforce. This creates problems in schools where the subject has to be staffed, sometimes with non-specialists who may lack the confidence to deliver effective science lessons.*
>
> *Students, if given a choice, would prefer not to study as much science. There are more attractive and less academically demanding subjects which students find more accessible. The lack of good science teaching (often through the lack of good science teachers) which is inspirational and which reflects ‘fun’ science as seen on TV and in the media and which has more of a real life context is not what they are exposed to in schools. School science tends to be more traditional and more ‘book’ based than students would like, they do not see it as relevant to them.*
>
> *I agree wholeheartedly with your comments in the section on key outcomes. The demographic of the students in question put science at a low place in their priorities for life, their own social circumstance and the difficulties they have outside of the*

> *classroom leave little time to engage in the notion of science being an important subject.*
>
> *Change brought about through imposed initiatives can only be sustainable where there is a clear recognisable impact (on learning or teaching or resources) which can be built upon as a foundation for and a route to progress. A school based initiative will be more likely to render sustained growth. However, low budgets, weak teaching, poor leadership, challenging students – all of these take over on a daily basis and staff who may be 'initiative weary' begin to resent the constant interruption to the status quo.*
>
> *Deputy Headteacher, Ashbourne School*

In Chapter 2, the issues surrounding government policy-making were explored, and it could be seen that many pressures from a range of agencies have been influences in the adoption of new initiatives for schools. However, there is little evidence that each initiative is researched before implementation or evaluated afterwards. Thus, the pressures on the DCSF (ex-DfES)[2] to encourage scientific literacy in society and produce a qualified workforce for science-based employment are well understood. However, the National Strategy failed to do this, despite the investment deployed.

6.3 Recommendations

The central finding from this case study is that the impact of the National Strategy had been insignificant in the long term, with the immediate impact seen in 2004 failing to take root and establish in the routines and procedures within the school. The reasons were clearly complex and multiple, but essentially the delivery of the Strategy was flawed in concept, taking too little account of the realities of school infrastructure and practice. The training was too rushed, and lacked the necessary reinforcement to embed key ideas into general use.

This failure could have been resolved had the National Strategy recognised the problem and been able to act upon it. However, the decisions taken by the Government led to a succession of new initiatives, thereby reducing the ability of schools to focus on the plethora of concepts within the Science component of the National Strategy.

If the findings of this study are replicated in other schools, and there seems to be every indication that this would be the case, then the recommendations stemming from the study are clear:

1. Any new initiative introduced into schools should be supported over a long term, and that the emphasis should remain on the key ideas until such time that these concepts are considered fully embedded into practice.

2. Schools should be allowed to focus on single initiatives, and not be subjected to a succession of diverse initiatives that compete for attention in the school.

3. Thought should be given to how teachers learn, and key ideas should be reinforced by repeated exposure, rather than single delivery to various individual teachers. The 'cascade' model for introduction of ideas has been shown to be inadequate.

4. The relative isolation of teachers, within department teams, within schools, within localities should be recognised. The structure and organisation of schools rarely presents real opportunities for sharing of ideas, particularly given the pressures and the shortage of time available in typical schools. As a result, teachers work in close-knit communities of practice,

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[2] Renamed DfE from May 2010

developing teaching styles and procedures suitable for their context. Any introduction of new ideas is inevitably faced with a natural inertia and resistance to change at a personal and organisational level. Because of this, countless excellent documents, resources and guidance documents are delivered into schools to join others on the shelves. In other words, the failure by Government to understand the nature of schools has thus far wasted vast amounts of time and funding for little tangible outcome.

As a corollary to this last recommendation, it should be understood that schools are not well placed to support each other. Teachers in any one school tend to have been only partially exposed to complex initiatives, and may have developed idiosyncratic responses to changes. Their ideas may not be transferable to other school contexts.

5. There should be a recognition that the status of science in schools and in the world of young people is affected more by what happens outside the classroom than within it. Consequently, it may be more effective to improve attitudes towards science by improving the public perception of science in the media and in employment, rather than by making changes to the content and delivery in the school laboratory.

6.4 Extension, and further research

This research has ultimately questioned the whole paradigm of educational intervention as it takes place in Britain. With high investment in a series of educational initiatives, it must be asked whether this can in reality affect student attitudes and attainment? Should there now be a paradigm shift where the educational establishment recognises that, without changes in the wider adult society, there can be no effective changes in schools? This would appear to be the case. In the teaching of science, as a component part of wider education for young people, a succession of initiatives and revisions of curricula have had little or no long-term impact, other than possibly arresting further decline in attitudes.

It would therefore appear that more embedded and systemic change in student attitudes to science might follow from a shift in values within the wider community. A study of this concept, delivering sustained improvement in attitudes and attainment in school through raised family awareness and changed values in the wider community, would provide a valuable insight.

The original delivery of the Strategy, principally through the cascade model of training (see Morrison, Gott and Ashman, 1989), has not had the desired impact. The issues have been well recognised since well before the Strategy implementation:

> In their concern with ‘improved’ curricula and ‘more effective’ teaching-learning methods, education ministries often use the ‘cascade**’** model to attempt to effect large-scale change at the classroom level. Experience of cascades in in-service development has tended to show, however, that the cascade is more often reduced to a trickle by the time it reaches the class-room teacher, on whom the success of curricular change depends. (Hayes, 2000: abstract)

Further research is required to identify the best mode for the dissemination of ideas and their eventual embedding into everyday routines within schools. Alternatives – such as in-house training for groups of teachers, followed by monitoring visits – may be more effective. The greater expense of this latter model has to be set against the apparent ineffectiveness of the cheaper cascade method.

Finally, it would be valuable to investigate the impact of repeated new initiatives (‘initiative overload’), not on the teachers themselves but on the implementation of preceding initiatives that are being delivered. Evidence suggests that one reason for the National Strategy being less successful than hoped stems from the impact of successive drives to implement other ideas. The impact of initiatives on teacher workload is well researched (eg. Smethem, 2007; Kezar, 2009) but the impact on the delivery of existing programmes is less understood.

6.5 Reflections on the study

This study has illustrated a phenomenon that was unexpected, and which does not appear to have been studied previously. In so much that this case study is representative of a wider picture, the study has illustrated the need for policy makers to reflect on the success or failure of new initiatives, and to make better use of academic research into the most appropriate models for delivery. While this may appear self-evident, initiatives have frequently been introduced with little consideration of why they may have been successful in isolated situations or in pilot trials before the national roll-out.

In addition, there has been a failure to recognise that a succession of initiatives did much to undermine the continued implementation of those that went before. Sadly, too many initiatives have been driven by an immediate response to a particular crisis (eg. Every Child Matters in response to the Laming Report) or driven by perceived issues which often have political undertones (eg. School Improvement Partners).

Top-down approaches are insufficiently responsive to local circumstances, and school-based initiatives are often only applicable to that single institution. A locally delivered and fully evaluated model for school development would seem to offer the best compromise.

This case study in Ashbourne School demonstrated the difficulties faced in the frontline of delivery of the initiatives, and the issues faced by this typical school illustrated the frustrations experienced by both teachers and students. Faced with everyday pressures and the difficulty of absorbing the messages into routine classroom practice, the National Strategy failed to transform teaching practice or student attitudes towards science. The case study therefore showed that the investment of considerable short-term expenditure does not guarantee long-term success of an initiative, however well conceived and welcomed.

Thus, Ashbourne School, a typical state secondary school with little to distinguish it from the majority of secondary schools in Britain, provided a unique study of how and why initiatives fail to have impact when delivered without thought about the methods by which the ideas could be embedded. It also illustrated the way in which subsequent initiatives have distracted teachers from the National Strategy, replacing their priority focus with other concerns, such as Personal Learning and Thinking Skills, Assessment for Learning, or Functional Skills. While each of these had merit, they reduced the capacity for teachers to consider the pedagogy of the Strategy. This could be seen in the discussions between teachers, and in the structure of their lesson plan sheets.

Thus, this case study contributes to our understanding of the issues surrounding the inability of the National Strategy for Science to have the anticipated level of impact, and shows how the lack of lasting impact, in Ashbourne School at least, this could not be attributed to a lack of initial engagement by the teachers. Indeed, the evidence from 2004 shows a strong awareness and involvement. Instead, this case study lays the blame on the failure of the DCSF to recognise the need to sustained training over a longer timescale, instead of replacing it with a succession of new priorities.

6.6 Reflection on research approach

The choice of a case study approach was largely driven by a pragmatic consideration of research methodologies that would be open to the researcher as a full-time Local Authority officer with an involvement in schools in the area. In the event, the use of a case study was extremely effective and allowed for multiple forms of data collection. This richness would not have been available to the same extent through other approaches.

A fully quantitative approach involving a spectrum of schools had initially been considered, but this would not have offered the depth of response and the ability to explore issues and determine underlying causes. The case study approach proved to be an excellent vehicle for examination of the National Strategy within a particular context. The selected school was chosen for being broadly typical of the majority of schools, with no particular features that would mark it as being different from the mainstream. Indeed, the recognised measure of progress (CVA) was exactly average for all schools in the year of the study (Appendix 1).

Alternative methodologies, such as an ethnographic approach of immersion into the department life for a period, or a linear study of changing student attitudes, were discounted as impractical, and the case study was considered to be the only viable option, as well as being the preferred method for the purpose.

It is felt that inclusion of other schools in a wider study would not have been beneficial, but now that key features have been identified in this school and suggested as widely applicable, these features can now be explored in other contexts.

Reflecting on the study more generally, the results were not as anticipated as the Strategy had been expected to have concrete and positive outcomes. The research therefore contributed a new perspective and an evaluation of the long-term impact of the National Strategy for Science in a case study.

A difficulty within the study – that of the time delay imposed by doing the research part-time – proved to be beneficial in two respects. First, the conclusion of the study (2010) broadly coincided with the termination of the National Strategy, and thus permitted an overall evaluation of the impact from start to finish. Second, the time elapsed between the initial stage of the research (2004) and the main phase (2008) allowed comparisons to be made between the time when the training was current and ongoing, and the time when any long-lasting changes should be evident.

The research was not without difficulties, and in retrospect it would have been better to alter a number of procedures in order to improve the collection of data. While the student questionnaires and interviews went well, and produced results that were both rich and valid, the teacher interviews and lesson observations could have been improved. The teacher interviews were semi-structured, but in the event the discussion was allowed to wander and the teachers did not always cover the same topics. While this could be seen as positive in terms of the responses, it proved difficult to correlate between the views of different teachers.

As for the lesson observations, it proved difficult to conduct the number needed without intruding on the work of the department. The lesson observations were too few for the depth of analysis that had been planned. Additional observations at a later date corroborated the findings, but the sample size in the research was smaller than ideal.

Despite the difficulties inherent in a study of this type, and despite the essentially disappointing discovery that years of intense work in schools had failed to produce the anticipated benefits, this case study has provided a unique and concrete evaluation of the National Strategy in an individual school, and has thus contributed a powerful understanding of the issues.

Closing:

What do I feel about the training? In the first year we were involved with it, it was very much sort of whole day, go along, which was very nice, day off school, etcetera. It would be interesting to evaluate the impact of that actually on, on …because in school the problem we've had is you sent people on a course, they come back but there's never any time to implement anything... So in terms of evaluating that, its been good, it opens your eyes, but it would be interesting to evaluate if there has actually been any impact, if its come back. It's like if you go on a course, its great, in lots of ways, but when you come back, back to the chalkface…......... ?

(Head of Department, 2004, reflecting on the cascading of training)

I was looking at my old book from my old school, and I was really good at science, I must of really liked it and the stuff we used to do. And I don't know what's changed, it seems, as you get older…when you're younger you get really excited, and in Y7, Y8 you get into a lab and think right I'm not used to this, I'm used to tables and a little… I don't know, little experiment we may do "How does Coke fizz?" or something in your old school. And you come into a new environment and you think to yourself, yeah, right, as you keep going with that same environment, and things start to slow down, and you think hang on, its getting a bit boring now, and I don't think (I'm) taking it in….

(Y11 student, 2008, reflecting on their experience of primary and secondary science)

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Appendices

Appendix 1	Context details of the case study school)
Appendix 2	Example Student Interview transcription
Appendix 3	Example Head of Department transcription from 2008
Appendix 4	Example Head of Department interview, 2004 study
Appendix 5	Example Questionnaire (completed

Appendix 1

Contextual background details for case study school.

The selected school was situated in a medium-sized county town in a largely rural area. The school has a challenging surrounding catchment, with many characteristics of deprivation, although superficially the area appears relatively affluent. However, the features of the student population are average overall.

The school is stable and is broadly typical in many aspects. These indices are shown below, with the national average figure if available:

Characteristic	**2006**	**2007**	**2008**	***Comment***
Number on Roll (NOR)	1060	1078	1105	School is growing slowly. School is larger than average
National average school size	983	982	973	
Free School Meals (%)	11.8	8.5	17.2	School is around national average for poverty
National FSM (%)	13.1	13.4	14.2	
Minority ethnic (%)	24.3	24.4	24.7	School has a slightly higher ME component than average
National ME (%)	17.0	18.0	19.5	
English as Additional Language (%)	13.4	10.6	10.9	School is close to national average for EAL
National EAL (%)	9.6	10.5	10.6	
Special Educational Needs (%)	24.7	22.8	22.9	School is close to national average for SEN
National SEN (%)	17.6	18.5	19.9	
Deprivation Index of locality	0.21	0.20	0.23	School is average overall in measures of deprivation
National average deprivation	0.21	0.21	0.21	
Contextual Value Added (CVA)	994	1010	1000	School is exactly median in 2008, being at 50th percentile
National average CVA	1000	1000	1000	
Percentile rank for English	86th	68th	68th	School is improving, and above average for mathematics
Percentile rank for mathematics	45th	35th	30th	

For this school, 36% of students come from a very deprived ward where 8.9% of adults have some Higher Education (19.2% nationally) and only 9.8% of households are considered high social class (20.1% nationally). Other characteristics for this ward are in line with the averages for England.

The other 64% of students come from a variety of wards where the context is broadly in line with national averages and in some cases they are relatively advantaged. Overall, the school is typical of the national picture.

The school population is 75.9% White British, and 11.1% Pakistani, with small numbers in a wide range of other ethnicities.

The rate of absence from school is 6.9%, which is lower than the national figure of 7.4%

Comparison of the Year Groups studied in 2008:

	Year 7	Year 9	Year 11
Number in year (NOR)	197	204	196
% FSM	17.8	13.2	24.5
% EAL	11.2	7.8	12.2
% skew downwards of prior attainment (at Y7) compared to national average	1.8%	8.2%	7.3%

This illustrates that there are no specific trends within the school, and that the characteristics of the school are not significantly different from many other schools.

Science results: trends

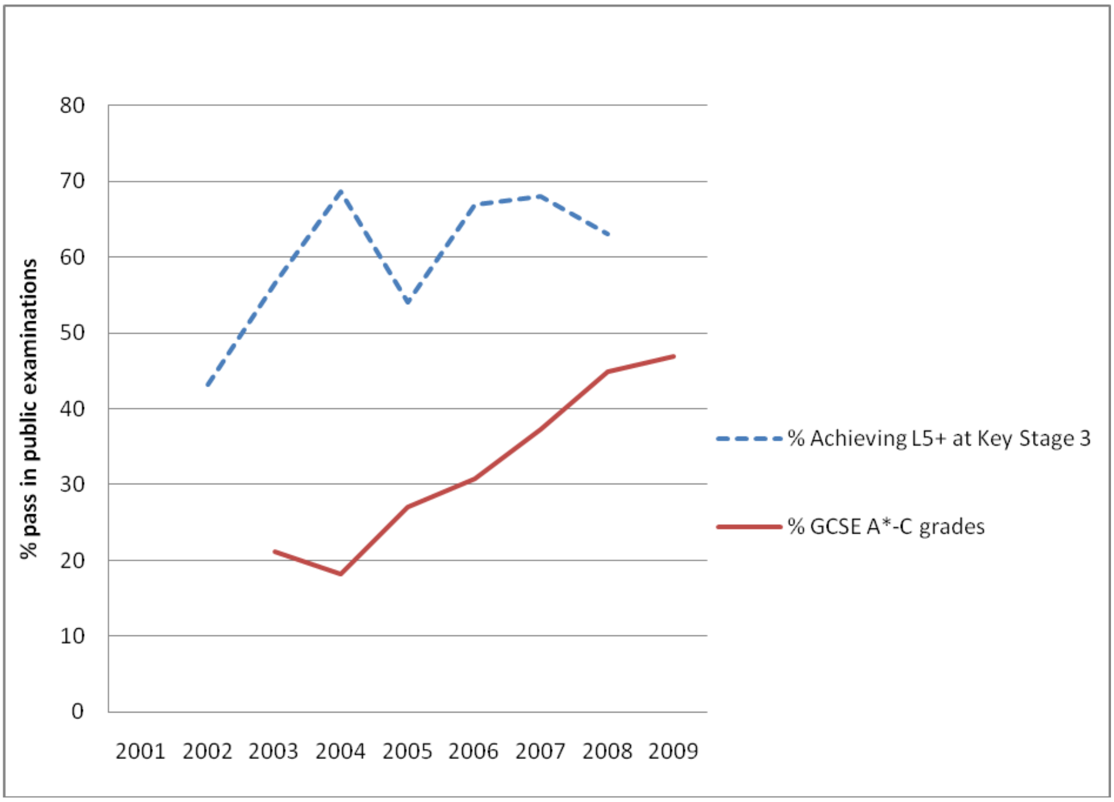

Figure 12: Science examination results in the case study school over the period of the National Strategy (data from LA)

The results show a significant pattern of improvement over the period, with Key Stage 3 results climbing to a position close to the national figures (see Table 2, p.5) and then reaching a plateau. For an upper school in a selective school system, this is a remarkable achievement. Similarly, the GCSE examinations at the end of Key Stage 4 rose sharply over this period, with a trend towards the national figure which was close to 60% at this time. Changes in the examination structures over this period make direct comparisons difficult, but it is clear that the science department made significant improvement over the years of the National Strategy. Attributing this change to the Strategy would imply a causal relationship, but over that same period a number of changes took place within the school, leading to a stronger focus on achievement in all subjects. In consequence, the changes were more likely to correlate to staffing changes and new policies within the school, rather than to the National Strategy alone. On the other hand, the dates of improvement in Key Stage 3 (2003 onwards) and Key Stage 4 (2005 onwards) would match the impact of the Strategy in this school.

Science results (2008)

Just 28% of students gained 2 or more science GCSE awards at A*-C grades, against 50% nationally. Some 42% of students gained at least one pass, against 62% nationally. This number represents students achieving the Core GCSE, while in previous years the calculation was based on achievement of double award science.

Within the school, the Relative Performance Indicator (RPI) or ‘residual’ for science was +1.7, showing that students made slightly better progress in science than in other subjects. These two features (below average outcomes, better than average progress) suggest that the teachers work well with a below-average intake.

Contextual Value Added (CVA)

The CVA takes into account a wide range of student-level statistics, including gender, ethnicity, prior attainment, deprivation and age. From these characteristics, the expected progress of students from Key Stage 2 to Key stage 4 is calculated, and norm referenced to 1000 as the national average.

In 2008, the school CVA was 1000.0, placing the school exactly on the 50th percentile rank for CVA, and thus the median for all schools.

This outcome for the summer of 2008 was obviously not known at the time of the study in the Spring term. However, it adds validity to the selection of the school as typical and potentially representative of other schools.

Appendix 2

Year 11 interviews.

Six students drawn from a science class, selected by the school to reflect ability range and ethnic diversity in the school. Full transcription of all discernable speaking, including sentence fragments. Interviewer in italics, students referred to by letter coding:

A – WB Girl - able

B – BME boy – middle ability

C – WB Boy – middle ability

D – Asian boy, able

E – WB boy, less able

F – WB boy, less able

Interview begins with explanation of confidentiality, purpose of the research, and reason for video camera. Students are given full reassurance of disposal of the film after transcription, and total anonymity.

1. What do you like about science in this school – what do you like or dislike about it? So, science in this school, what's your views about that?

2. D: Well, in general, to be honest, I don't like it, only because they don't make it fun to learn. They make it very book orientated, so you just have to read and read and write and read, when science may be fun, you could go outside. But I'm not going to mention which teacher because I think that's just a bit mean, but she [confused giggle] …when we ask to do experiments, we sometimes don't have enough equipment for it, we don't…we just don't have the stuff, but she doesn't try to make it interesting for us to learn, so I think most people get put off by it, which affects our grades

3. A: And I don't think we have enough time throughout the year-group to complete the course, which is partly why we don't get to do the practicals, and we just learn the theory instead of actually learning it for ourselves.

4. OK, that's great. So you've identified shortage of equipment, OK, you've identified teaching style, OK, and you've identifies shortness of time. Is that correct? OK? Lots of other people to comment

5. C: I think er science in general is actually quite a boring subject. I think, I think that it could be made quite fun. I don't think teachers here make it fun, at all. I just think its read out of a book and learn it that way, and that's about as far as it goes.

6. OK, so you also think its quite book orientated..

7. C: …its very book-orientated [all nod]

8. B: I think science can be good but teachers need to put more effort into it [C: Yeah] and it should be more of an option, because I know out of English maths and science, science is the worst. Like that's my opinion, it might be other people's opinion as well. I just think if its going to be one of those essentials, they need to make it like better, or make it more…. It seems like…we're just doing a project about polymers and stuff like that.. I..I..I don't know what I'm going to use that for, I don't know in my future life what I'm going to use polymers and whatever their called for. And it just seems if we are going to learn it, spend less time on subjects like that, and more time on more important subjects.

9. C: that you need to know

10. B: Yeah, like the, like the Global Warming and stuff. We do, it does come up in a unit, we get told so much about it, but there's no-one doing anything about it really, so then we think to ourselves: why are we learning this? This is stuff that we know. And a lot of it does seem to be going over stuff that we have learnt before, alright in a little bit more detail, but it just seems repetitive [D: Tedious] as you say keep reading out of a book and working.

11. *That's good*

12. E: I just don't like work in science, because we do summary questions and we don't do no experiments, so its all in books.

13. *So questions but not experiments?*

14. E: Yeah. So summary questions, a, b, every lesson

15. *OK, so what's your feeling?* [looks at F]

16. F: I think science is boring, its like we don't do no experiments or whatever

17. *Right OK. That's a pretty, kind of, unified view there. I'm interested in what you say about some bits of science not being relevant. OK, if we learn about polymers, why would we need to know about polymers in later life? I'm sure there must be bits of like history, you know, that you learn, or geography or whatever, that you think when..why do I need to know about this? Why do I need to know about the First World War? Why do I need to know about life in Nigeria? Or something like that. Do you not think that all subjects have things that you don't see the immediate..*

18. B: Yeah but that's why they are options. History and geography are options. I know I didn't like either of the two really, that's why I didn't pick them. That's why I think science should be optional. Obviously its good to know what's around, its good to know about carbon dioxide and oxygen and everything, and what's around you, it is good to know. But in history it is good to know what was there before you and what happened in history, but its whether people want to know that or not.

19. *Yeah, that's interesting. So….*

20. D: Reading from his point, as he said, it should be optional. I don't think all of it should be optional, like we've got optional Additional Science. I think, we think, I think we should have science, but what we learn in science, as we said, we should have, do the important things, and the less important things should be optional, you know what I mean, the subjects in science itself, as in Global Warming, as in some things we need to know about the World, like some aspects. But I don't really want to know about all the rocks and what's..all….why do I need that in my life [shrugs] if I don't want to be a rock scientist? [general agreement]

21. C: I want to learn stuff about what this World is coming to. Simple as. That's what I want to learn because at the end of the day its going to be me that's living in it, me that's growing up in it, isn't it, so why not learn about it? I mean we might learn a bit.

22. B: Part of me thinks, how do scientists, even with all the stuff that they know, how do they know what the World is going to come to? How can they tell us, when its not been 100% clarified? I just don't like knowing things that I'm…that I've been told is going to happen and then its not been 100% confirmed that that is going to happen.

23. *No, I'm sure that people, scientists, will make their best guess, you know, on the basis of evidence, and science is about using evidence to try and draw a conclusion from it, OK? So whether you're looking at rocks and saying "Well, I think this rock was formed by a volcano or formed under the sea, and so on. By looking at the evidence, what can I tell?" And that's really what science is all about, OK, rather than just the facts, which as you say, you probably won't use, OK, which is fair enough, OK. Now, um, the second question was what parts of science do you like best? And what do you dislike? Now I think that you've mentioned many of these things already. Is there anything else you can say about what you like in science, and what you dislike in science, particularly?*

24. E: I like doing experiments, because you learn how to do them, but when its just copying out of textbooks, its boring. Just plainly(?) every single lesson we do it

25. *Right OK. So, experiments, you actually like doing the stuff (All: Yeah) OK, nods of agreement from everyone.*

26. D: I like creating things too. Like, in chemistry you get to create like new little chemical things, all the colours coming up, fizzes, it just makes it more fun to learn. Like when you put the lighted splint in it, pops, you see that's, I think that's the best bit.

27. *OK. Yeah, yeah…*

28. B: I think if you get involved with the science, if its actually you involved with the science, and you doing it, it makes it more interesting, rather than sitting down having to learn about it. Because I know I've sat down with a book, doing questions, and thought "Why can't we do this?" And the teacher said "Oh, there's not enough time" Well, then it should be planned out that you can make enough time to do different….I think if there was more..more….more.. more practicals, it would become more, you think, I've got a practical to do in science, because after all that's one thing about science, you don't do practicals every day. You may have PE, you may be playing basketball, you may play basketball every day of your life after school, but I know I'll never do an experiment, say magnesium and popping it, and lighting it on fire and stuff. So I suppose if you are more involved with the science it would make it more interesting.

29. C: It would make I a lot more interesting.

30. A: I don't like the, the whole year group of us, sat out as one, um, we're all like the same learners, because we're not. I know that the majority of the year group are kinaesthetic learners, so we prefer to do like experiments, but we're not given the option, so it would be good if half of the class who are kinaesthetic learners could do the experiment, and if you don't want to do the experiment, you could do summary questions.

31. Right……That's a staggeringly mature thing to say, I mean, kinaesthetic learners, I mean, have you talked about your learning styles? [Yeah, agreement] Right. OK, crikey, I'm a bit bowled over by that one! [laughter]

32. B: I suppose we can't put it down to everyone's kinaesthetic learners, but, er, er, on behalf of the year group I could say if you sat us in a room and you said, the majority of the students, and you said, right, we're going to do this experiment or you can sit down and you can read, write about it I'm sure about it [C: I can tell you about it] 95, if not everyone would be like yeah, OK, let's do it. Because that's the thing that is good about science, that, um, you don't do something like that every day. Like I said, science ain't something that you're always going to come across. So I think if we're… if it is going to be essential, they need to make it interesting, and make people think OK I used to like science because we used to do this that and that and I learnt how to do this, rather than yeah we used to do like we used to do in English, practically sit down and do questions. So…

33. Yeah, right, OK, that's really useful. So the third question I'd written down here, What would make science more fun? – then OK we're thinking about, from what you say, experiments, yeah?, and we're thinking about relevant things, like Global Warming, but not things that you can't see applications for, you can't see how that relates? Yeah?

34. B: I think if you're going to put something like that in, they need to find a practical in it somehow.

35. D: Its not only about practicals. I do find it fun to do something like a debate or something, instead of just listening to the teacher talk. We don't have to do a practical every lesson because that's not, not, [confused interjection from all, including I'm not saying do a practical every lesson] But anything like that, debates and stuff, and different ways to learn instead of just writing, because we could have experiments, do debating, go outside, so many different ways of learning…

36. B: Science seems like its one thing, which is….well, maybe two, because you get experiments as well, but science predominantly is copying out of books and that, and learning from the books and we learn….you can't do practicals in lessons in history or things like that, [C: yeah] if you get a lesson where you can do practicals to learn about it, it's a nice change, rather someone shoving a book in your face and saying right…

37. Thanks, that's really good. Um…..What would you say was a typical lesson in science, OK, so you arrive, you walk in through the door, OK, teacher's there, what happens? [several interviewees put hands up]

38. C: Get the books out. Teacher tells you what page to turn to. Read through it as a class, or read through it as a class individually, [affirming sounds from all] read through it as a class, answer summary questions.

39. D: Our class reads like that.

40. A: Our class, we have like the teacher talks us for half an hour

41. D: Yeah, she lectures us about exams first

42. A: We get dictation, lectures and stuff. Sometimes we get shouted at and then [D: she'll talk about the work] she'll talk about the work for ages, and then we get told to do all the questions, and then summary questions..[B: yeah]

43. D: Summary questions we get like ten minutes to do, because she's already spoken for all lesson..

44. A: copy them….

45. B: I think really it's down to teaching styles [C: yeah] different ways of teaching, rather than just teacher at the front – obviously they've got to be at the front, they've got to tell you what you're doing – but rather than the teacher keep talking and talking and talking – that's usually what our typical lessons are like, teachers basically telling what we're doing, and then you doing it. It just, like, just drags on, and you think oh, I've got to go in and do the same thing over and over again [C: it is just exactly that]

46. E: I think they put so much pressure on you about the exams, when you could be doing experiments, like come into the lesson, copy off the board, open a book and do all these questions.

47. Hmmm. So, um what is seen as being a good start for a lesson would be to arrive and then have what's called a 'starter' activity, like a ten minute activity at the beginning to sort of …. Excitement, a quiz, you know, a little game or something like that. OK? Would you say…. Er…. that you recognise something like that at the start of a lesson?

48. All: Yeah [nodding]

49. OK, so, so, lessons do begin with some sort…. Most lessons start with some sort of starter?

50. C: When I used to have maths, er, when I used to walk in we used to do a relevant activity on the interactive whiteboard, like on the internet, maybe it was a game or maybe it was anything like that – we always used to do a starter activity for about ten minutes. That would get us settled for the rest of the lesson. As soon as that, we would learn, we would do good at what we were doing.

51. B: But even so, with starter activities, because we do have some, usually people come in, depending on like what period the lesson is, it will be like, everyone's overexcited, or they're being loud. Even if its just ten minutes at the beginning, say its just something on the board, even if it's just there and that ten minute period is just for everyone to calm down, set their mind into gear, "right I've got to do science now", and I think out of the ten minutes maybe it should be like a five minute game or something and five minutes to get everyone settled first, because I know a lot of our class we come in and we're rowdy and then Miss gets annoyed, and it ends up "oh in a minute we're going to do the questions", well we're going to do the questions anyway, I'd rather do them sooner. So I think the teacher just needs to be more, more, [A: mutters] yeah, open-minded.

52. Open-minded. Yeah, OK, um, you do recognise though that science, at least some lessons do start with a starter and [All: yeah, affirmation] I know this is hard, but what percentage of lessons do you think, in science, have some sort of starter?

53. D: Do you mean fun starter, or just general starter?

54. *Just general starter, some activity at the beginning*.

55. B: Fifty fifty for us..

56. D: 55% for us [general laughter]

57. OK sure, about half. Something like that, OK. And in terms of a fun starter, because you differentiated that, how many how many do you reckon have something fun at the beginning?

58. E: Not a lot

59. A: One a month

60. B: About five in the whole year

61. C: Yeah probably

62. *OK, right, the other thing about lesson structures is that with about ten minutes to go before the end of the lesson, that you should stop and then talk about what have we learnt today?*

63. C: It never happens.

64. *It never happens? [all shake heads] OK, right.*

65. C: In other subjects, yeah, but not in science.

66. *In other subjects but not in science? That's quite critical…*

67. B: Sometimes it does happen with us, but that would be like two minutes before the end. And then like the buzzer..

68. C: the buzzer's going…

69. B: and then the buzzer goes, and we're still talking and we're thinking come on we've got to go, we're getting out of science, can we just go to our next lesson [C: Yeah] and they just drag it on and on and on. So if they were to do that, it would be good to do it ten minutes before [C: ten minutes] not ten minutes after.

70. C: It never happens really. How often does it happen with us? Hardly ever.

71. *Hardly ever? Right.*

72. C: In other lessons it does, but not in science.

73. D: I think our teachers are set in their comfort zone, and are scared to go out of that comfort zone. Because they're so used to doing things with a ritual, they're so used to doing things…. They're frightened that if they do go out of the box [C: Change] we won't learn…

74. B: I think we should teach a lesson, personally….

75. D: Yeah, but that works. We did that once, we took turns for a week, teaching lessons, [C: I did; B: I taught a lesson] because our citizenship teacher, she does a special thing called Study Week, and once a month the children teach the children and because, she says, the best way to learn is to teach, because you have to know the subject to teach the subject. So, if we had something like that in science it might be….(tails off)

76. *Right so, yeah…..that sounds a really interesting thing….I mean, um…..I have to say you guys are really articulating things particularly well, I'm really pleased with this…um….How do you think lessons in science compare with other subjects? I mean, are there other subjects that you would describe as boring, like you describe science, or are other lessons in the school actually a lot more fun? How does it, how does it kind of compare?*

77. C: (raises hand) Some of them are good, some of them are boring, it depends what lesson you're in. It totally depends what lesson you're in, what teacher you've got.

78. B: D'you know, that's what I think it is. I think its down to the teachers really. Because I know, I've had different maths teachers, some maths lessons have been come in, and like mellow talking, mellow talking with like each other, my maths lessons now we go in, be quiet, we do the work [C: So quiet] in silence, and I think it is, I think its down to the teachers. I reckon science, more people would enjoy science, but I think its different teaching techniques or whatever need to come in. But I think obviously you can't be like, oh, everyone talk, do what you want, we're not going to learn science, obviously you can't do that. That's just not necessary at all. I think there should be a time where, maybe a student teacher shows how different ways you can do it, and how you can make a lesson fun.

79. C: It totally depends on the teacher and the subject.

80. D: Its also personal choice [C: Yeah]

81. *That's true. Obviously, I guess I would probably hate PE, me, but I would love art, you know, whatever, different people, but…*

82. C: In the subjects I don't like, I can still get along with it, if the teacher's got the right attitude, and is willing to help me to learn, [B: It is that] I would still learn it, I would still, still work my hardest at it, even if it is the worst subject and I hate it with a passion, I would still work my hardest at it if the teacher gives me the… if the teacher lets me learn, I will learn. If the

teacher does say right sit down look at a book, I'm not interested, I'm looking out of the window all lesson, d'you know what I mean?

83. Absolutely, right, yeah, yeah. Definitely. [B: (quietly) That is definitely right] Would you say that science is an important subject, you know, for you, for the World, and so on?

84. E: Well it is, and it ain't, depending on the job you want to do when you're older. Some jobs are related to science, and some are not. It all depends on what kind of job you want.

85. C: And it depends what you learn in the science as well. Some of the things I'll never use again, ever. But some of them, like Global Warming, I do want to know.

86. D: And Healthy Eating as well.

87. C: Yeah, I do want to know that.

88. B: I think it is important, even though it's one of my worst subjects, that I don't like. Even though in some things, like and knowing how to draw conclusions from things, and when you're doing practicals, and when Miss says those dreaded words "Right now we're going to do the conclusion" and you think "Oh God" is actually, I have to admit it does actually show me that I can draw conclusions and things. And it is good to know, because it just makes your general knowledge much better, and it is, it is important. And I know some people say I'm not going to be, I usually say I'm not going to be a scientist, why do I have to do it. Like its just the fact you're getting more knowledge inside you and you're getting more, you know what's around, and you know what can happen if you do this, what can happen if you do that. So I suppose it is important, and it is right, it just needs to be made so much better.

89. C: And I think we should learn much more of the subjects that mean more, like we said, like Healthy Eating, and things like that, that's things we need to learn about. And like Global Warming, people need to learn about that. Its not just a matter of "Yeah, its in the teaching curriculum, we need to teach it". People need to know. [Sure, sure] When we grow up, when the people in this school grow up, they don't know what's going to go on in the World, so all this talk of Global Warming and everything, maybe you learn two or three lessons at school about it and that'll be it. You don't know anything more than you ever did. OK so maybe there's more greenhouse gases, maybe you've learnt a bit about that, but that's it.

90. D: He's got a point about, when he's talking about drawing conclusions, I don't know if you meant it in the same context, but each subject's linked in a way, in science we sometimes use maths, and English does help you in your logic, I think its logic, or maths could be logic as well, but it kind of helps with your writing skills as well, which helps with the English, so I think that it helps that we have science, obviously, but, as he said, just important subjects rather than (waves arms, voice fades)

91. B: Its not just about important subjects. Like, anyone could turn around and say lets pick out a curriculum, lets pick out, I don't know, dieting properly, um, Global Warming, what happens in the World, stuff like that, even things like, I didn't like it really, like products from rocks, we've just done, [All: yeah] I really didn't enjoy that, but at the end of the day I've got that in my head now , what is, what is, it is good to know what is around you, and I have to admit, even though you might think Oh God, I really can't be bothered, it is good to know about, or rather than when someone says something, you say "I dunno, what you goin' on about? I don't know nothing about that". And it is good to just have that knowledge inside, so although we would, anyone would like to just come to science and do certain things, that we think, WE think, we need to know about, [C: Personally, personally] but I think the more knowledge you have, really, the more aware you are, and the more it all just, I can't think of the word, it will all express your mind, basically, and you've got more knowledge going into it, and it just makes you more aware of what's around you.

92. D: Him saying that makes me, hmm, yeah we don't need to know why trees are green, but when you look around you think why is it like that, why are [C: General Knowledge]

93. Yeah, yeah, I think, think that science is part of the current understanding of the World you go about, go about in and perhaps there aren't things that you think you immediately want to know, like different types of rocks, you mentioned earlier, OK, well sure, but sometimes when maybe you're digging your garden or going for a walk and you see a stone, it might be useful *to think of that as being a particular rock, rather than just a 'stone', just like nothing, yeah, yeah,*

94. C: It's quite funny though because as we say it, I look over there and I look at all the plants and they are facing towards the window, and its like, well I only know that because its science, it gets attracted towards sun, creates photosynthesis, etcetera, etcetera [B: Well done; all laugh] so if someone was to ask me, so I could tell them, its general knowledge really, it does help you out a lot in life, like how to grow plants, and stupid things like that….[All laugh, stupid]

95. Yeah, yeah, I think you're right. I'm sure it's quite unlikely that at some stage in your life someone's going to come up to you and say "can you explain the photosynthesis reaction", well that ain't going to happen, OK, but it is useful to think if your plant isn't growing very well, maybe I should put it on the window sill [C: Exactly, yeah] *OK, that's fine, yeah, yeah. I think I probably know the answer to this, but the next question is can you see yourself studying science in the sixth form?* [All: shake heads, no] *Right, nobody. This is a great concern because the Government sees science, technology, engineering and maths, OK STEM, s, t, e, m – sees those as being real growth areas for employment in the future, a real need for people with those skills, OK?*

96. C: Not at this school.

97. Not at this school? OK, right. (laughs). Right. Is it your experience before, that puts you off doing science in the sixth form?

98. C: If I'd of had a very good experience before, maybe my opinion would be different, but I wouldn't know, because I haven't had that experience.

99. B: I was looking at my old book from my old school, and I was really good at science, I must of really liked it and the stuff we used to do. And I don't know what's changed, it seems, as you get older…when you're younger you get really excited, and in Y7, Y8 you get into a lab and think right I'm not used to this, I'm used to tables and a little… I don't know, little experiment we may do "how does Coke fizz?" or something in your old school. And you come into a new environment and you think to yourself, yeah, right, as you keep going with that same environment, and things start to slow down, and you think hang on, its getting a bit boring now, and I don't think taking it in…. and because the more sort of interesting and not paying, as you go up, saying the big question, someone saying to you, would you do this in the sixth form, ah you think is it going to be the same, I haven't really worked as hard. If…Say for example I was thinking about doing it, and I wanted to do it. But then I thought to myself Hang on, did I enjoy it? Did I enjoy it before? Did I put in enough effort before? Did I learn what I needed before? And it's a case of, at the time, you're maybe thinking Oh, I can't be bothered and I'm just going to get it done and out of the way. And if you want to after, that's your prerogative, but I think if you want to do science, you'll do it from beginning to end [C: Yeah] and you will keep pushing at it, same way if you're into acting, you'll push forward and keep going in the sixth form, business, and any other subject.

100. A: And if science had come across as more than a book subject from the beginning, from Y7, then more people would be inclined to do it at sixth form, because they would be more interested in it.

101. Sure, sure, certainly. Can I just ask what you think you might do next year? Some of you might stay on at this school, some of you might be going elsewhere. Can we just go through and ask

102. A: I'm going to do business and…. I'm not sure, this school doesn't offer very much…. Business and media.. maths maybe, English lit., and something else, I don't know…

103. B*ut here, OK? Here, so, so are you planning to study those subjects here?*

104. A: no, because they don't offer them, [So where would you study them?] The Fxxxx.

105. Fxxxx, OK, yeah.

106. B: I'm staying here. [What do you want to study?] Business Studies, but I want to do Drama as well, but there's a big fluff up at the moment and they're trying to get it so you can do both of those subjects, because they clash at the moment, so hopefully they're going to change

that. But I like this school, I like, I'm used to it. And I think if I like, if they are offering me exactly what I want to do, what's the point of me going anywhere else?

107. C: I'm planning to go to Axxxxxxm College and study Production Arts and also ICT at the same time, that's like a (?) course, you can study Production Arts there, on a two year course, and on the day you have off, you can go ahead and do ICT. [Brilliant, OK]

108. D: I'm going to do Maths, Economics, Dance and Theatre Studies, but at the Fxxxx, because this school doesn't offer anything…. [OK, sure, sure, sure]

109. E: I'm going to go to Axxxxxxxy College to study Catering. [OK, brilliant]

110. F: I'm going to Axxxxxxxy College and like do Landscaping, or whatever [OK]

111. OK, excellent. That's really brilliant. Just trying to get something now about what you think about science, not in the school, but outside, OK. What do you think of scientists? If you thought about a scientist in the outside world, what kind of image comes to mind?

112. C: A man, in a white jacket, down to the arm, with glasses on, looks like a right nerd. [All laugh]

113. D: That's Einstein, frizzy hair.

114. C: (points to picture on wall) Looks like that.

115. Exactly, yeah.

116. B: I think of someone exactly stereotyped as well, and that, I think of someone that likes science, who is trying to make a difference to the World, but had more of a push, that was their thing that they were going to do.

117. C: You think of someone who actually has no social life [B: You do, yeah] That's what I do think of.

118. B: See me, say I…say I want to push with Business Studies. I can see me with a briefcase, suit, shoes, sunglasses, Bluetooth headset, whatever, what have you, and people may think oh he's just a bloke who's business all the time, but that's something you want to do, you want to push for. If you want to do something, you'll keep going, go for it, same way if you want to be an actor, you might see someone in not, not the bestest clothes, [D: All black] but they're walking around, trying to find that part. The scientists are now trying to find where they want to be, so I do, I do give respect to them, because it's a tough job, but someone's got to do it.

119. Sure, sure.

120. E: Its people like Steve Hawking trying to like unravel the Universe, and how it strarted, and that.

121. *Hmmm. You see I…. most people have this, kind of, stereotype image of a scientist, exactly as you described, OK, a bloke, little round glasses, probably on his head [yeah] white coat, pens in the pocket, OK, ambling around,* [clipboard] *clipboard, yeah, no social life, bit of a nerd, OK* [C: Always spends his time in a laboratory] *yeah, and, and, socially inept, probably doesn't have a girlfriend, etcetera, etcetera. OK. Now do you actually think scientists are really like that, or is that like a kinda joke stereo type, but deep within you, you kinda know that isn't true?* [All nod, yeah]

122. D: Yeah, I know that isn't really true, but when we were younger, that was our stereotype, that was all we knew. But now in modern day TV, you see more scientists on TV, I don't know (unintelligible) CSI Miami, but you see them in a lab, and they aren't ugly, they all look quite good looking, they don't have big frizzy hair, glasses, [jumbled comments] but that's probably how they look, normal people..

123. A: There's different types of scientists. So I think there's like the extreme scientists who really really love science, and other ones who only do it for a job.

124. Yeah, yeah. I mean, most…Most scientists are about as normal and wacky as any, kind of, pop star or whatever, and and are as interested in their job as someone who's interested in kind of like, I don't know, selling cars or making money on the stock exchange.. I mean, so I'm sure that really we all know that deep down science, scientists are kind of normal people and have exciting lives and so on. But they get a bad press don't they, you know, the sort of *portrayal in James Bond films and so on, they're always the baddies, they're always kind of up to no good, and so on, or they're complete nutcases…*

125. D: If you think about it, we're all scientists in our own way. Because when we're little kids, if you remember, we used to explore our own world, we used to dig in the ground, we used to see what's inside the ground, and that's what scientists basically do, they observe the World, they make things, they look at things, so we are all basically scientists in our own way.

126. Hmm, hmm yeah, that's incredibly mature. That really is true, there is no hard and fast sort of dividing line, and most jobs you go in to, at some stage, will draw upon your science, OK, so if you are doing art productions, or suchlike, you will need to know basic science of how to plug things in, what lights to use, and so on and so on, so you might think, oh, I'm not using my science, but actually you are, but you just kind of don't notice it, OK, so yeah. So what do you think is the influence of science in the World? Do you think science, as a kind of enterprise, is overall good or bad in the World?

127. B: Good

128. Good? OK

129. B: Good, I think it is. One of, if not, nah I wouldn't say THE most, but I think one of the most important things that you need to know about. Because if you go and say I remember science, I used to hate science, but there's stuff that you know that's in your head, and so if anything did ever happen, you think oh I know why that's happened. And I think it will just pop up and you don't know. Some things will just happen and you remember, oh I know what to do in this position, so I think it does pop up when you don't realise it. [Yeah, yeah]

130. C: Nearly everything you hear on the news relates to science, everything, everything, in the long term relates back to science, if you look at it in perspective everything goes back to science, there's always science involved in something, whether its that computer over there, or this floor over here, its all been chemically bonded, all things like that, you know what I mean….

131. Its really funny because the Y7's I interviewed they said oh, we should get rid of scientists, and I said oh, if there'd been no scientists, you'd be sitting in a cave somewhere [D: We'd have no doctors] *you, you'd be coming to school on a horse. I don't you can disentangle things, but, but, science as it's portrayed on the TV and news, do you think it is portrayed in a positive or a negative way?*

132. B: Positive, definitely. Because even if you watch CSI Miami and that.. forensic scientists, key word, forensic scientists, if say your brother was killed and you want to know how he's died, you need, you need someone because if you think to yourself wait I don't know anyone, oh I should have paid attention, I would have known what to do, but you've got someone there who can examine your DNA and all that and who knows all this stuff and can help, so I think yeah that it is..is..good that we've got it and I think its right that we do keep it.

133. C: It helps with everything, even crime, like he said, DNA, things like that, like this new thing they've invented, smart water, that stains your skin, shows up in UV light, for two to three months, so if you go anywhere, steal anything, this smart water comes and you don't even realise it, stays on your skin, police catch you, take you into their UV room, put it on and they've caught you.

134. Fine, excellent. That's pretty impressive stuff.

135. C: There's a lot of stuff

136. D: and there's that laser, when you come out of the airport, instead of showing your passport, they're going to show your eyes instead…

137. C: That's all science.

138. Yeah, yeah, I was quite impressed by those Mosquito things, that only young people can hear. [All: yeah, yeah] I thought, God, that's really impressive, you know..

139. C: They had them in Aylesbury, they had them up town, round by the fountain, this sound that only people like under 18 could hear to deter you from going to this one place where everyone used to hang around. And then it stopped people, and I was sitting there with my dad one day

and I said just come on we've got to go, and my dad couldn't even hear it. My dad couldn't hear a thing. Very clever.

140. B: Little things, if you look back, look at your favourite games console, look at my X-box, I love X-box, so I say to myself, if we didn't have science, would I be playing X-box, or would I be sat with a book and a pen in front of me.

141. D: Playing with rocks [All laugh]

142. *That's why you need to know about rocks!* [Laughter]

143. B: But I think it is important..

144. C: It is important, you're right.

145. I know it's a while back now, but you should have studied science at primary school. And, um, because the National Curriculum for science was in, and it was expecting you to be taught in a certain way. Um, what did you think about science at primary school? I mean did, did..

146. E: It was quite interesting because we mostly done practicals at our school, we learnt about plants, and we went to the darkroom and put all stuff, and we went and done photos and all that. [Brilliant]

147. A: I think because you were young, you were more interested, but in our school, I was never that good at science, so I was never really interested, so I don't remember much.

148. OK, but you do recall that science did happen? [A:Yes, we did science]

149. C: Its just still, just still exactly the same, science hasn't really changed much, its always been book-orientated, its always been something to do with that.

150. Sure, sure. When…

151. B: I can remember, in my primary school, science used to be another subject, it was quite exciting, because you used to think I'm not learning this usually, but as soon as, you used in Y6 right at open days in these schools, as soon as I saw, because you usually don't take much interest, as soon as I saw what science could be, it did actually get me more excited, and I used to think there's more we can do. [Sure, right.] They just, I think, but obviously you can't put all these big experiments into primary schools, but if you keep them guessing, keep them coming, and as soon as they come in to secondary school, they will enjoy it. So maybe it weren't that good in primary school.

152. C: It's got to be from, it's got to get interested from the day you join, I'd say from the day you join secondary school, or maybe Y6 or Y5, it's got to be interesting from that day to the day you leave.

153. Absolutely right.

154. E: When you do science in primary school, you don't actually need to learn a lot, but when you get to secondary school it's all dumped on you with these exams and that [C:Yeah] Gets much harder, you come into the real world in a few years..

155. So you feel that, that there's more fun and exploration at primary but at secondary it's more exam-orientated, more learning facts and so on, is that right, yeah? [E: Yeah] When when, if you can imagine when you came here in Y7, right, can you imagine, you were only this big, OK, right? What did you think science was going to be like?

156. B: Amazing. God's gift

157. C: These things, like Bunsen Burners, gets you really interested.

158. B: I remember. My first lesson was sat down, I'd been talking to like olders I used to know, like cousins and that, they said don't listen to this teacher, she's horrible and that, sat down and they pulled out a Bunsen Burner and I thought it was Christmas, because your not used to it, it's a new environment, it's a new environment, same way if you was into football and you used to play just a little bit, and then someone takes you to a big stadium and says there you go play here, you'd say Waaah, I've just hit the lottery. And that's what it is, and it goes from that spark and then you start thinking it ain't as good as a couple of months ago, then it comes into Y8 and you think it was really good, I hope it lives up to expectations, oh hang on this is a

bit…. By the time you get to Y9, you've got SATs coming up in science, all right, you try, you try to concentrate, and you see there's more bookwork, by the time you're in Y10 you've given up, by the time you're in Y11 you're trying to pick yourself back up, because you've got your GCSEs coming up…It sort of, it goes… if it was on a graph Y7, Y8, Y9, Y10 (draws descending slope with hands) and then its trying to pick yourself back up. [C: At the end of Y9..] Like throwing yourself all the way down and then trying to pick yourself all the way back up for your GCSEs and that, I think that's hard, I think that's where it drops, because it just seems repetitive, all the things that happen in it.

159. C: Like he says, as soon as it hits Y9, and you've got your SATs, that's it, and that's where the book work really starts, you get bored with it.

160. B: And when the SATs are gone, you just Arrgh, I've done it now, I can relax

161. C: ..and then it's Y10 and GCSEs, and you've got right down there, and you have got to pick yourself up to get into science, like he said, because you have got to try, to do your best to get a GCSE in it [lots of talking at once]

162. Because interestingly enough, you are the first year group to go through on a new GCSE, you are guinea pigs, OK, because the new science GCSE started in 2006, which is when you started in Y10, OK? And the idea was that this new GCSE was going to be a lot more kinda interesting, and it was related to the real world, and so on, and so on. And you might be saying God knows what the last one was like, OK, but are you saying that you're not, not that impressed by the new GCSE?

163. C: I have appreciated having an exam what every, I think, three months, I have liked that, because you've not got to get to the end of Y11 and revise for so many subjects. It is quite good, doing that, but you're still, you're still down there (points at floor) sort of thing [Yeah, sure]

164. D: I don't know if it's just our school, but the teachers, when they can see a child is really good at their subject, um, they seem to focus on them more often, and I don't think they should. Like in English, they've got a set of girls, only girls, not boys, who got B's in their mocks, who get a separate [A: They've changed it] who get a separate class to improve their grades, when people lower than B's you don't. In science you can clearly see the teacher helping the people who are going to get A*s whereas the people only on C's and D's are just like, you are still down there, I'm not going to help….

165. C: They don't want to help the people who need the help the most…

166. B: I know that largely, I don't pay attention in science much [C: You don't though, do you!] Do you know, do you know what I whittle it down to is the teachers, because I know, even this morning, like this morning it was registration, and he went you've got science now and I went oh no, I can't believe it and here we go, so we go into science, and we sat down, and the first thing that happened was a book got thrown under my nose. And I looked, as if to look up and "oh my, someone help me, please" [C: Page 288]

167. D: Do you know how happy I was when someone called us out, I was so glad to leave them [laughter]

168. C: We were just the same

169. B: We can't really sit here and

170. A: I was just going to say, um, I think they planned it to be practical and really fun, but because we haven't had enough time, because we're the first year to do it, they haven't thought it through, they haven't thought oh they need this much time, so we've just overstepped usually this much work in this much time, and the teachers haven't planned it out properly, because we always get told we've only got two months left to do like that much work, and its not enough time.

171. D: And when we do have enough time, to do work, they throw an ISA on us….

Bell goes to end session. Profuse thanks given to the students.

Appendix 3

Interview with Head of Department at Case Study school Summer, 2008

Date of interview was several years after the delivery of key Strategy training. Interviewee had been a teacher at the school throughout the training, but had only recently been promoted to Head of Department..

Italics: Interviewer.

1. *Er, Ok. This is an interview with the Head of Department. The first thing I want to talk through with you is the impact of the National Strategy. The National Strategy for science was implemented from about 2001 onwards. When did you come into teaching?*

2. 1999

3. *OK, so you were in the classroom at the time of the introduction of the National Strategy?*

4. Yes

5. *Fine. What would you say now were the main features of the NS at the time, as it was presented to schools?*

6. Er, the three-part lesson was the main part that we learnt about. It was the structure of the lesson.

7. *Would you say that it had much impact on lessons? If you went about the department, or thought about your own lessons, would you say that you could definitely see….?*

8. Oh, yeah, definitely. Both the starter is brilliant for captivating the students, particularly those who have been introduced to different ways for starting lessons, and different types, so…That's quite good for captivating them and then the plenary at the end of the lesson for a form of assessment, so you're not always relying on bookwork.

9. *Yes. Right. Now that was obviously a key part of the National Strategy. Are there any other messages or themes that came out from the NS that you think well that was a feature as well?*

10. Er, a couple. The first one was Misconceptions *(yes)* We did quite a lot of work and went on courses on Misconceptions which proved really beneficial because we were able to locate areas of misconceptions that we weren't always aware what was happening. And it also allowed us to spice up some of the harder to teach topics. I think it was the ideas, the main part of the Strategy.

11. *Do you think that as a result of that teachers are more reflective about teaching, or do you think there hasn't been much of a change?*

12. From my point of view I think that they are. I know that I try to think about ways that I've taught one topic, and think "Let's see whether we can do that another way". Because previously we used to be very much "Open the book, this is what we are doing, read and answer some questions". That's the way teaching was when I first came into it. *(Sure)* And now teaching… teachers are trying to make their lessons a lot more captivating. I think that's down to the Strategy. And its taken a lot into Key Stage 4 *(Sure, sure, yes)*

13. *I'm sure that what works in one Key Stage certainly is likely to work in any other, yeah. Do you think that, if you actually think about student attitudes and the way that they engage in science lessons over the span of time, if you sort of think back to when you started in '99, to now, sort of eight years on, would you say that you think that student attitudes to science have changed in any way, for positive or for negative?*

14. Er, I think in this school that they have. I don't know whether that's an overall thing *(Sure, sure)* Again thinking back to when I first came here, the attitude and motivation of the students was really quite low. The cha…the intake of the school has changed however, so it might be down to the intake we're getting, or whether it is because science is being made a little bit more exciting. *(Yeah. yeah)* I don't think I could give a decent answer on that.

15. *Yeah, I agree. It could be that we've got…. it could be a different intake, it could be different teachers, and management, it could be an impact of the Strategy, or it could be perhaps101 things,*

16. Yeah. So many, so many things. I think, erm, I think because of the way they've been taught in primary schools, and then coming up to us, there's the similarities, because everyone's using the 3-part lesson, that's probably helped them.

17. *That's really interesting that you should mention the primary schools. Have you, er, would you say that you have noticed any change (a) in the intake and what they know and (b) have you adapted what you teach here in Year 7 to take into account any of those changes?*

18. I think the main thing I was quite clear is that they know about the 3-part lesson so they are expecting… they see it in a chunk, they expect a starter, and they expect at the end of the lesson a plenary. Other than that, changing our Y7 work, we haven't really done that. That's one of our…[laughs] …targets.

19. *Have you had a chance to get out into primary schools to have a look at what's going on?*

20. No, no I haven't. Something I'd like to do more work on is transition, because we've spoken about transition a lot, it's just getting out there.

21. *Yeah, I think that, on a professional level, you'd find that really, really rewarding. You know, it's just great fun to see what's going on. Some schools are actually switching teachers, so you can have a day in primary school, and one of their teachers comes and teaches here.*

22. I've heard about that, and I think that would be really good.

23. *Yeah, anyway that's, that's…. Now, um, the implementation of the National Strategy, er, was really driven, initially, by training days, a whole series of opportunities to come out of school and go along to training days. And more recently those have been cut right back, and instead allocated more consultant time, the consultant spending days in school, working at the chalkface. Do you feel, first of all, do you feel well supported by the National Strategy in what it is trying to do, or do you think it could be better in any way?*

24. No, I think the support is brilliant. Its just as you need it really, because most of us have been out on the courses, so you come back all keen and wanting to do it, and then when the consultant is in school you can implement that into your lessons or your scheme of work. The support is very good *(Sure)* and there is always someone there at the end of the email or phone *(Yeah)*

25. *If you…Um….Are there any, sort of, plus and minus points that you could identify for the training day model?*

26. The plus point is when you're able to, er, obviously the more consultancy time in school, there's not so much work over in the Teaching and Learning Centre *(Sure)* and I get to go over there quite a lot, and mingle with other schools, which is very useful. I need to get more of the

middle team to go over there and mingle, because you can pick up some brilliant ideas. So more opportunities to get together with other schools *(Yes, yes)* and…

27. Yes, that's a real plus point of meetings, in a sense, or training days in that you can network with other people and tap into their ideas and resources. Are there disadvantages with going out on a training day, as opposed to having work done within the school?

28. Oh there's - going out on training days - there's major disadvantages in leaving potentially five lessons, being covered, and students can sometimes lose the flow of what they are doing, and the lessons again are going back to the good old-fashioned bookwork while you're not in….

29. Yeah, yeah. And what about the dissemination of what you've learnt from the training day? That's traditionally seen as being quite difficult.

30. It, yes, it depends on when you've got available time to have a meeting. If you've got a department meeting or learning team meeting coming up soon, you can pass that information on. But from a whole day, to summarise it quickly in 20, 25 minutes isn't *(Sure)* isn't very easy, but when we went there most of the time there was an extra sheet that we used to feed back, which was good and then we centralised all our work that we picked up, so you could flick through someone else's folder and see what they'd been doing *(Sure)*. But it wasn't easy to feed back to everyone..

31. Cascading is traditionally seen as being quite…

32. Very hard.

33. Yeah. Yeah, That's brilliant Now, um, if you, going back to the lesson, you identified various things that, that you would say are features of lessons around the school, that stem from the National Strategy (Uhum) *OK, so if we just think about that for a moment, identifiable changes in lessons, you've already mentioned 3-part lessons, so going around your department you would expect to see a starter, main part of a lesson, and a plenary* (Uhum) *OK, um, quite a difficult question now, how confident would you be that someone going around your department would see that, pretty well most of the time?*

34. Very confident.

35. Good. OK, that's fine (Yeah) *Brilliant, because there's a tie-up between what you want to happen and what actually does happen in practice, and that's an important thing. OK, now beside the 3-part lesson, are there any other things that you would say "In lessons in this school, that's a real strength, I feel very proud about the way people do x or y within lessons."?*

36. Um, probably group work. *(Right)* That was a thing that we introduced from the Strategy, more group work, structured group work *(Yes)* so that we were able to give the students time to talk about it and share opinions, because obviously, as you know, in a class they won't always talk to the teacher. So when you put them in small groups and ask them to do a task, I think that's something we do, well, some classes do better than others. *(Sure, sure).* But I think that group work is quite positive for us. Same with peer assessment, because that comes along with the group work. They are more likely to comment on each other's work once they've swapped it over, mark it, give themselves a comment, and pass it back. It's quite good, they know what they're supposed to be looking for then *(Sure, sure)* That's another one.

37. Yes, yes. And do you think that these sorts of elements within lessons have a real impact on engagement, how the, how involved the students are in a lesson? Do you think that has changed at all over the years?

38. Yes, they are definitely more engaged in lessons because its so… we said about the 3-part lesson, but the main part of the lesson is still split up into different sections *(Sure, sure),* and because the lessons we're now teaching are a little bit more snappy, the students are constantly having to concentrate, and there's different tasks focussing on their different

learning styles (Sure) so I think it does engage the students, there's something that each of them can grasp from each lesson…. If the lessons are taught properly (Yeah, yeah).

39. *Would you say that differentiation happens in lessons?*

40. Yes. Again it was a bit of a hesitant 'yes' because I think it depends on the teacher and the class….and the subject – some subjects are very difficult to differentiate. *(yeah, absolutely)* But yes it should be happening and we do have it happening in the department.

41. What… Have there been any barriers, that you could identify, that actually made it difficult to introduce changes into teaching styles? Anything about the school or the department that actually slowed down change?

42. Erm…. [long pause]….the first… I think finance really slowed us down, in this department, because you need some things to help you out, to make your.. to do different parts of the lesson, like data-logging equipment, whiteboards to show clip-its of films and moving-around tasks. So finance was a major thing, and I think there was a slight barrier with our older, already-structured teachers, who didn't want to update their styles. They were already set in their ways and that worked for them; and if it worked for them, why change? So I think that was something, but now everyone's all doing what we should do.

43. Yeah, now, resistant staff, who have taught in a way in the past which has been seen as successful, is often the major barrier for change and actually slows down the introduction of ideas (Yeah). *Were there any things about the department that actually made it easier to bring about change, or to make that change painless, or faster?*

44. Yeah, I think the major thing for this department is how close we are and how social the department is *(Yes),* so everyone was very keen to say "Oh, I tried this, it didn't work, so I'm going to try it this way" so therefore you weren't on your own trying to introduce a new change, it wasn't just down to department meetings to show your ideas, it was happening break, lunch, all the time, and because we are quite a close department you could nip in and watch someone's lesson and steal their ideas *(Yes).* And I think that was really good. So being a close department has really helped.

45. In some schools they developed quite a strong, what is called a 'Community of Practice' where within a department, say, everyone is talking to each other and developing ideas and suchlike, which may in fact be going on in a slightly different line to a similar community working in another school, but nevertheless within the school you actually have a group of people who are pretty like-minded and therefore this sharing process is well-understood. Do you think that people share more now than they did in the past?

46. Yes. Because sharing good practice is part of what you do now, all the time at meetings.

47. I can remember when I started teaching, that the idea of using someone else's ideas was seen as being 'theft' – "Oh, you stole my idea"….

48. [laughs] And also you want to be the best teacher, so you keep the good ideas to yourself. Someone thinks "Wow, they're fantastic" when in fact a fantastic teacher is one that develops these good ideas and then passes them down. *(Absolutely, yeah, yeah)*

49. Now I'm quite sure there's a big role in the Subject Leader or Head of Department in creating the atmosphere that you describe. And would you say that since you took over the department you have deliberately focussed on these things, or were they already in place? Or were they just happening anyway?

50. They were in place in some parts, because we'd all been on Strategy training and our consultants had been in. We all knew what we were supposed to be doing, but the sharing of work, and the extra things, weren't embedded as*…(Sure)* everyday tasks, so hopefully, I've managed to roll that out and I think I've had quite an input, but there has been stuff that's been underlying here, that just needed a little tweak….

51. *So, you personally changed your teaching style over the last few years, Ok, and you've got, er, you described the 3-part lessons, and group work, and peer marking, and that sort of thing, and you would feel quite strongly that your colleagues share those views, share resources, and teach in broadly the same way* (Yes) *OK, that's fine. Now, at the end of the day, a critical factor, in the success of all this, is does it actually change student attitudes? Because the Government is absolutely desperate to produce more kids who are keen to do A level sciences and go on to study science, or certainly have a big component of science in what they do.* (Um) *Now, do you think that student attitudes, or their views about science as a social activity, as something out there in society, do you think that their views about science have altered at all over the years?*

52. Erm, I think with the new…what was previously happening was in Key Stage 3 they were very switched on to science, they were very keen, and when you got into Year 10 and 11 it just died down. With the new scheme coming out there's a lot more relevance to everyday science *(Sure)* a lot more thinking skills being involved, so I think now there's an improvement *(Yes)* just coming in *(Right),* but I think previously there wasn't so much because I think it just dropped [motions with hands] *(Right)* after Year 9

53. *Now that's actually really interesting. Um, so you're saying that the Key Stage 3 Strategy, as it was, actually created exciting lessons and suchlike, but the old GCSE was a problem, but the new ones that came in two years ago are much more engaging…*

54. Yeah a bit more thought provoking. Very much you can leave it as a group task, you can get people's ideas and there's no desperate right or wrong answer for some of the questions and I think that does help because they go out and they are all questioning things and asking more and wanting to find out more information. *(Right)* It's like my lesson this morning was exactly the same on that, on extinction, and they all wanted to ask for extra websites to look at. Which is very unlike what they would have done before*, (Sure)* with extinction it would have been so very boring, so I think it is getting better.

55. *Now which, um, course are you following for your GCSE's here?*

56. AQA Science A and AQA Additional Science for Double Science.

57. *And did you teach the Core in year 10 and the Additional in Year 11?*

58. Yes, they do unless they are doing single science.

59. *What….and at the end of Year 10 what were the outcomes?*

60. Of the top of my head I can't remember [laughs], but much better that what we've had previously, and obviously this year they are doing a couple of resits because they didn't put them all through and certificate it yet *(Sure)* but I think the ISA's, that's going to help, because its actually down to the students' understanding rather than what they are going to get off the internet *(Yes)* as before so, yeah, its much better, this scheme.

61. *Now, we've kinda identified that much of student attitudes to science can be moulded in the classroom and the relevance and how exciting the lessons are, and so on and so on. Just as an opinion, do you think that pupil attitudes towards science are driven by, firstly, their peers, you know, the other..other children saying "Wow I really like science or yew, I hate science", or do you think it is driven by wider society and how science is portrayed, or do you think it is driven by employment prospects. You know, I'm trying to focus on what makes, what is the ultimate driver for whether a child thinks they want to go on to, you know, with more science or whether they want to drop it here and now.*

62. I think it has to be the wider community, simply because some students like science and some don't, and it doesn't matter when they are friends or not. Employment prospects, it would be lovely to think that they are thinking that far ahead. Some come up with "I want to be a doctor" or something, but they don't think that far ahead. I think if they have an environment around them where they are watching nature programmes or programmes that question their thinking,

maybe parents or adults at home are asking them to…their opinions….. I think anything where there's…they have access to reading, looking at papers, and…then they're the kind of students that go and question and enjoy science, but as we know our intake aren't those kind of students here. We don't have many that would be sitting at home reading the newspaper with their family *(No)* and discussing Global Warming over the dinner table. I think, sometimes its just down to a matter of curiosity, those students who are constantly wanting to learn something, if they are coming into Year 7, something grasps them like an enthusiastic teacher; unfortunately Year 7 and 8 students like a subject according to who they've got, I think..

63. There's a lot of truth in that, which is why, the nature and the characteristics of the teachers is a really important factor that you can't remove from the equation, you know, you constantly hear kids say "I really like…geography because we get Mr.X"

64. And he's really good fun..yeah

65. And this sort of thing, and obviously their attitudes are very much moulded by the individuals, and sometimes you find they won't take a subject that actually they would like because they don't like a particular teacher (Yeah) *so that's a problem obviously. If we, if we wanted to further increase the number of students who go from GCSSE into science A levels and hopefully beyond, what….can you think of anything, either about the children here, or more widely in society, can you think of any things that would encourage children to consider science A levels?*

66. I've been thinking about this, like, for mad, because we really struggle to get students on our science courses. I think its very much down to where they want to go, making sure of, they are aware that science A levels or Key Stage 5 qualifications open a few doors for them. (Yes, yes) They need to realise where they could go with it, so trying to publicise more, you know, job prospects, because as you said before, that's something that could captivate them, but some students don't even think about potential job prospects until it comes to leaving school. Once, I think, once the new scheme has been running a few more years, and they are thinking a little bit more deeply, I think some of them will might to further it and go on to study A levels. But I don't think there's an answer on how we can increase the uptake…

67. No. If you wanted to do one or two things within the school, to improve students' perceptions of science, can you think of any things that you could do, here and now, and say like we could try that….?

68. I think I'd try something like running an assembly, just to say this is what science can be like, this is what you can do with science, just to like publicise it a bit more, you know a few more posters, signs around school, let them know a science qualification will do so much for them, and how fun science actually is *(Sure, sure)*

69. Its quite difficult and I have to say (Really difficult, yeah) *that students being turned off science is a feature of, er, the more developed countries, OK naggingly, globally, and so it doesn't matter if you are talking about Japan, or America, or whatever, they've all got the same problem.*

70. I think it's also a little bit of laziness, as well, they've got through their GCSE's and they think science A level is going to be much harder *(Yes, yes)* and they are scared by the amount of work and they don't see that the reward is at the end, and they can go and do a BTEC in Business or something, and get told they are going to get 4 A levels for it, and that's a lot easier, and when they are comparing the two subjects together, hard work and get one A level, or sitting on the computer and doing something quite simple, and get 4 A levels, you know, any student can see one route is easier, and if they haven't got a point at the end they are aiming towards, like potentially going to do a science degree, then there's no point doing science, in their eyes.

71. Yeah, do you that students feel that sciences in general are so much harder than other subjects?

72. Yes, definitely, yeah, yeah, the hardest thing you can do is an A level in science.

73. Now, changing pupil attitudes is a key thing that we want to explore with this. What I would hope to do at some stage, is to talk to students, talk to teachers and explore with them what their views are, and whether the students….what are the students' views about science as a general thing and whether they think the lessons really kind of 'push the buttons' and make them engaged (Yeah) *which from what you described makes it sound like it will be true* (Hopefully [laughs]) *which is really important. Now just to sort of round off, I mean, there are a number of things about student attitudes that are real important factors in their future choices. If we were to think of the children in this school, what elements do you think would be real drivers for their interests? What do the kids here really think about?*

74. Practicals. Anything that goes bang. Or involves a Bunsen Burner. It's a very simplified way of looking at it. Secondary school, all they want to do is play with Bunsen Burners, and it runs straight through to Year 11. So the more practical work they do in a lesson, the more fun the lesson is. So if you are teaching evolution / environment kind of topic, the lessons are boring, unless you spice them up. So anything – they are quite kinaesthetic our students so you can do something that's card sorting games, or matching games, but they prefer to do anything practical.

75. Now do you use the data projector for showing video clips and suchlike in lessons…?

76. Yeah, yeah, I did that this morning. I showed the trailer from Ice Age this morning *(Ok yeah!)* doing extinction which certainly captivated them, they came in and were straight on it, thinking they were going to watch the whole film.. Bless them, they were so disheartened when they found out it was only a trailer, about a couple of minutes,

77. Sure, do you think that that technology, and the changed teaching that enables, do you think that is a powerful factor for them?

78. Yes, definitely. Anything that can capture interest will be quite powerful with these students, because you can switch them off quite as quickly though.

79. Yes. OK, so there are risks with the technology, just endless PowerPoints and, and…

80. Oh yes, the PowerPoints when we first started using them were very captivating, but now you can show 2 / 3 slides, the best slides, and you move on to something else, you've got to keep their interest.

81. Sure, sure. OK, that ends the structured part of the process. Now are there any things that you can think of now, that you would want to raise, and say that when you are talking to the children, or when you are talking to the teachers, can you ask about this? Are there any things that you would like to know about the department?

82. It would be interesting to know how easy people find it to level work, because that is something we picked up, we did an awful lot of work from the Strategy, but coming back to school and doing it, you can be given an example and get a group of experienced teachers sitting round saying "Oh that's a level 5" and you can tell them the DEAL ways of doing it, but….whether people actually can level work without giving tests straight away *(Sure)* Because when there's inspectors in, or we could say more often "This work is level so-and-so" but finding that out is quite interesting, and finding out if members of the department actually do know, because you say level work regularly, and I don't think everyone can *(Sure, sure)* Because I know I take a long time to look at things and try to break it down

83. That certainly is a very difficult thing, and one of those things where there are no short cuts, it's a time-consuming exercise to look at a piece of work and think carefully, does it hit the necessary criteria for level whatever..

84. Yeah

85. How often would you say, estimate, that teachers mark exercise books?

86. Every three weeks

87. Three weeks…

88. That’s what we’re supposed to do. Every three weeks we’re supposed to put in a structured target and a comment, rather than just tick – the overall ticks should be done quite regularly. Its not always stuck to, the three weeks, but so long as they are marked regularly, that’s what we’re supposed to do.

89. OK. I’d like to thank you for your time….

Interview ends.

Appendix 4

Interview of Head of Science, Phase One School, Summer 2004

This school is very similar to the selected Case Study school. The interview date coincided with what would turn out to be the climax of Strategy training.

Italics: Interviewer.

1. *Basically what I want to talk through are some questions about the National Strategy and just going over these, er, there's no right and wrong answer, its just very much a matter of your view, your opinion about things, what are your first thoughts. Right, I'm going to start off, um, what do you understand are the key features of the Key stage 3 National Strategy?*

2. What I see is the key feature of the Key Stage 3 National Strategy is this: um, historically, if we are to make advance in terms of the teaching and learning in the classroom, the, the, the people who need to be challenged, to be honest, are the teachers in the practice and the way that they do things. And the Key Stage 3 Strategy is about challenging, um, how shall I say, er, practices from the past, you know, people who have been in teaching for a long period of time, set in their ways so to speak, so I see the KS3 strategy as looking at, working in partnership of course, but looking at the way people teach, and see if they can improve upon it. But its about partnership, its not about prescribed, you know, you must teach it this way. Um, so I see it that that's the main thing the Key Stage 3 Strategy is ultimately about. And of course a range of um, raising……attainment, and I say attainment because it is a numbers game as opposed to what it should be, what it is, about really is raising achievement…but that happens because..

3. *There's an attainment focus*

4. Yeah.

5. *Are there any specific things that you can identify and say, OK, yeah that's something that has come from the National Strategy that we've, we've implemented in the school?*

6. Three-part lessons. Fundamentally important the three-part lessons. There's also the, I think we adopted it anyway, But I think that the, the, its recommended that everyone follows the National Curriculum. You don't have to, but it's the recommendation. But I think there's that move towards everyone delivering the National Curriculum, you know, using whatever framework you want to choose, but actually delivering the National Curriculum for Science, I think is really important, because I think its actually very, very good. But it's the three part lesson I think, which I think is really important, um, it's, it's also the order and the analysis that's actually been very helpful, because it's very easy to plan in isolation without actually looking at the strengths and weaknesses of the department. And what's been very helpful is the KS3 consultancy is coming in as a critical friend in some respects, an objective observer, and saying look, this is the analysis we need to do, and the way we plan. It's done in partnership, so I see them as good examples….

7. *Excellent. Yeah. What do you feel about the, the, training that's been offered as part of the strategy?*

8. What do I feel about the training? In the first year we were involved with it, it was very much sort of whole day, go along, which was very nice day off school, etcetera. It would be interesting to evaluate the impact of that actually on, on …because in school the problem we've had is you sent people on a course, they come back but there's never any time to implement anything. Um, that said though, there are one or two of the modules which are specially for, sort of, the, er, teachers new to the KS3 maybe, either ?? or individuals, whatever. Which I think has also been helpful to immerse them into the KS3 strategy, I suppose. So in terms of evaluating that, erm, its been good, it opens your eyes, but it would be interesting to evaluate if there has actually been any impact, if its come back. It's like if you go on a course, its great, in lots of ways, but when you come back, back to the chalkface…but what we've done in the second year, we've managed here, we've managed in ********* to get…well we identified on the timetable a slot of time where everyone was not on timetable, non-contact time, and we've developed a, what we call development time, and we meet once a week, where the focus is…it's not just KS3, it's KS4, but its targeting down to teachers, and talking about teaching and learning, and leave all the mundane but important, of course, paperwork to the half-termly meetings, etcetera. And that's been very effective because the consultant's been able to come in, and then would give us a one lesson session on…er….let me think of an example …um ….mapping …science 1 skills, talked us through that and then we have the next two, three weeks to implement it. I found that really really had a big impact, because everyone was part of the whole process and we were learning together. The other thing I thought was very useful was the whole days off the timetable, the whole department….we weren't able to make the first day, which was rather unfortunate, but we were able to in terms of the second day. I thought it was good because it allowed you to network, not only with your own staff, which you should be doing anyway of course, but across schools and stuff like that, so I found that was very, very good.

9. *So really the cascading of the information initially was a problem. I…I…*

10. To be honest with you I think it was. It was, it was, everyone was very, very busy. It was because there was conceptually, there were major changes…now as you look back and now actually, you know, it's now happened at the time and what's now being suggested is making ******, at the time it was quite radical changes that were being proposed, we look back and think the three-part lesson is a radical change from the practice before to what it is now, you know, I think it was quite radical, you need time to implement it, and then get other members of staff…..the key to the success of that bit was getting the Head of Department has got to be enthused, and focussed, and want to change, otherwise it's just, it's just window dressing.

11. *I'm sure that's right…..In terms of the Core days, and having whole departments off together, some schools were kind of uncertain, I guess, about whether that was time well spent, you know, a whole training day committed to the Strategy. Others have been very strongly behind it..so ..would it be fair, I think, from what you said, to say that you appreciated the Core Days?*

12. I..I appreciated it in two ways. For one, it's, it's very easy for Core Day, for…for Inset time to suddenly become admin time for school or, you know, other focuses. The beauty of the Core time was it meant that you focused on one thing, that was your subject and delivering the curriculum, teaching and learning, I think that…. Because it ring-fenced the time, that's what made it really powerful.

13. *Where the training day has been attended by just one person, how, how, if at all, has that been fed back within the department? Has that been….has that really worked at all?*

14. In the first year no, to be really honest with you. In the second year, usually because of K*****'s persuasive, er, methods, just just keeping in contact there has been a move to try and incorporate it. But to be honest I ..I wouldn't say particularly effectively really (no) A lot better with K**** coming and getting involved, with our sort of Tuesday lesson two's every week, you know, it actually allowed some, but, you know, if you asked me the question, of all the people who went on all the courses, how much, how, how, many of them actually had the opportunity to feed back, actually I'd say less than thirty, forty percent. *(OK)* Actually, I'm not very proud of that, to be honest with you, but its time.

15. *I wouldn't worry about that, because it's a very common picture. What would you say had been the impact of the Strategy in your school, I mean, d'you think that there's been an identifiable change in lessons? I mean if you were going into lessons…*

16. Just within science or across the school?

17. *Yeah, yeah, we're talking about science, yeah,*

18. There is, yeah, I think there is, because there's, there's, there's subtle changes that came about with adopting the National Curriculum, the strategy of three-part lessons, and I would, I would, I would suggest that it's simple things it's about staff are now focusing on outcomes, what are we trying to achieve here, rather than the objectives, you know, we are now going to cover the following, what are the outcomes whatever. I think there's a notable difference there and, and and you know,…….this will probably give the wrong (unintelligible, technician enters the room, distracts interviewee)….Is, is very very clear shared objectives for students, which I think is really important, erm….. So I think there is, there is very noticeable differences, er…and because we've adopted the National Curriculum hook, line and sinker, and the schemes of work and everything that's tailored to that, it follows it sort of naturally, but in terms of the methodology of the teaching I'll say it's had a big impact, it's not good enough just to deliver a lesson, it's a matter of having a framework and focusing on literacy and numeracy and stuff like that, it doesn't happen every lesson, it's important because you're constantly remembering (gestures inwards with hands to show inclusion), it's got to be covered, so to speak.

19. *Yeah, yeah, yeah. Do you think that the teachers think about their work differently now?*

20. Teachers think about their work differently……

21. *I mean, d'you, ….for example in some of the pilot schools it was said, that the teachers instead of sitting around, in the prep room at breaktime, talking about individual naughty kids, or, you know, talking about football or whatever, they, they, they instead were starting to talk about how to teach, and suchlike, er, I mean do you think that the teachers, actually, are more concerned now, outside of the classroom, are thinking more widely about what teaching actually is.*

22. Erm, yes, to a point, I think the Tuesday meetings we have, because we've said we'll go round the room and give one good lesson this week that you've had, so you're sharing and talking about good practices…In terms of the staffroom itself, I wouldn't say there's been a marked shift towards let's talk about good practice in teaching and

learning *(no)* but there definitely is, and I think, more an openness to cooperation…and I mean it could be because of the nature we've organised in terms of the scheme of work and stuff like that, and what I've tried to encourage in year seven and eight, we do the whole curriculum, so you're having to teach outside your specialism, so I think there's, there's …opportunity at breaktime, such, we do talk about it…but the biggest thing is time, really. There has been a marked change from there's this naughty boy (unintelligible), *(yeah, yeah),* but we do try and move towards it, so I'd say, in the Tuesday sessions we have, we make a point of talking – that wasn't me that brought that up – I think it was K*** or V***** who said let's make a point of one lesson we'll talk about, individually, just one minute each, one lesson this week. And it's amazing how it builds you up as a person (yeah, yeah) to talk about what we do, which is teaching and learning, and the rest is just window-dressing, I suppose (yeah, yeah, sure, yeah)

23. *Are there any barriers you can identify, that have really made it difficult to implement the Strategy, in this school? What, what sort of things have, have worked against you if anything?*

24. What has conspired to hold us up? Err….There have been a few issues, errr….Generally the school is very supportive of the Key Stage 3 Strategy. Ultimately it is judged by the results in English, maths and science, so it's got to be. But that said, there have been a few problems, one of which is, the money that cane directly to the school, four and a half thousand pounds, or whatever the amount was, which was fifteen hundred English, maths and science, for the Heads of Science or whatever to spend, we were very fortunate, I found in a lot of schools (mumbles, shrugs) but my main point in saying that, its our money, I want it. In the first year we were able to pay teachers to do Booster classes, after school and at Easter, and that actually had an impact. In the second year, er, where control of that was taken out of my hands, it was taken by someone on SMT who is non-core, erm, different sort of emphasis, we had a big moral debate on whether we should pay teachers or not. …Well, my view is the money is there, it's called Booster money, for Booster classes, you should pay teachers, and I had an ongoing three-month debate about whether you should pay teachers and ultimately, you know, every argument I put up, you know, was shot down, um, but I still believe, maintain the moral high ground in terms the money was there to pay teachers to deliver lessons. We still did it, right, but it would have been nice if the money that was put to the school could be given to teachers to reward for what they were doing in terms of their extra time. You know, there are moral issues, and ethical issues possibly, but I thought they were immaterial given what the money was allocated for, so that's been a bit of a barrier. The other barrier, that's been the Core Days, the first Core Day was really key that we'd go to not newly qualified but non-English trained teachers and I think the Core Days, as a department, have been useful. Decisions were, were um taken within the school that we wouldn't be doing Core Days, and I felt that was a lost opportunity. I would put it down to, in the first year or two, the Key Stage 3 Strategy was basically left in the hands of the people delivering it, the heads of English, maths and science, and that was effective, we were given the autonomy to get on with it. Once that autonomy was, was, was taken higher up the ladder, it was no longer such a priority, it became a diluted priority ultimately, and a frustration to try lobbying, look, and what I did, or what I think, personally, is that one of the three heads of the curriculum areas should be nominated as the Strategy Manager, rather than a person on SMT, but that's only a personal perspective…

25. *So who is the Strategy Manager?*

26. It's K******** E********, and she's a non-core, she's a PE teacher, you see, so it's not the same focus, really, and it wasn't seen as such a high priority, and there's other thing…you know, a very hard working person (gestures juggling) eight balls in the air, where we were given freedom of action before, and this was all pulled to the centre, where I've directly liaised with K****C*** for instance, I then had to start going (gestures a series of turns), you know, which you work round the problems, but it was at times I found quite, not quite constraining, but constraining.

27. So… the, the key things you're saying are about money and the way that was allocated and um, the er, fact that the Strategy is now being handled by a non-core person who has essentially different priorities. (yes) What…um…are there any things about your department that you would say have really made the implementation of the Strategy easier, than it might be in other schools, you know, make it more painless?

28. I would say having a Second-in-department who focuses on Key stage 3. (right) I did it the first year, but I was doing everything else, Key stage 4 and everything else, and I was acting Assistant Head for a year. By, um getting a second-in-department, V****F**** who took on, initially, sort of as an oversight of Key Stage 3, and she's taken on board, and she's totally, you know, totally, um, ridden with it, and I prefer to… everything in Key Stage 3, that's her side of the wood, I let her get on with it. And I think that's really helped, actually, because you've got one person, at the right level, focusing on a really, really important key thing and she has autonomy to decide what's going to happen.

29. Mm, mm. … How…What about you, yourself….so an effective teacher in an effective department, how, how have you adapted your own practice as a result of the Strategy. Thinking in terms of your own lessons, thinking in terms of the way that you are managing the department, what's changed over the last two years?

30. What's changed, um…………..it's, I suppose…..what's changed? It's very easy to write a scheme of work, what's changed for me, maybe it's a personal development thing, is, is the focus on outcomes – what are we trying to achieve here? – I think its really important, if you understand the outcome, you can plan for that outcome. If you have an objective, usually you don't achieve the objective, because you lose your route on the way to the objective. So I think, for me, its been a subtle change towards what are we, an outcome, what are we trying to achieve, what do we want these students to take away from the lesson. That's the first thing. Secondly, funnily enough, and again this is possibly my own personal development thing, I'm a great believer, being a scientist, classroom full of kids, and my chemistry set, and its my job to, not job, but I like to experiment with new ideas. And the beauty of the Key Stage 3 Strategy is to make people start experimenting, I suppose, trying new things. Um… You've got the comfort zone of a framework, which is three-part lessons, objectives, etcetera, but that's the starting point for let's, you know, let's experiment with new things, hence I'm involved with this from a marking thing at the moment, looking at assessment for learning, rather than assessment of learning. So it's made me look more… in terms of that. Another area, is well, plenaries. One thing the department is very bad at, but we're getting better, is plenaries. And it's made me focus on plenaries. Um, I'm doing a Beacon School project using video cameras to, for the kids as their own researchers, where they interview during a lesson, during a practical, and they, the ideal is, well it doesn't happen in every case, they present the plenary. But because the Key Stage 3 Strategy has actually made a very clear distinction between starters, plenary and middle, etcetera, it's, it's made me focus on the parts of a lesson rather than the whole. The worrying thing is a lot of students still

think trying to research science they deal with it in some way, they leave at the end of it. They don't see it as three parts. And I'm sure in every case, it isn't the case,…

31. *I think it's still, you know, very much the case in many children's mind, that, you know, when they get to the end of the experiment and the teacher has got them to pack up, that that signals that is the end of the lesson, and they don't imagine that the last five minutes is an important five minutes.*

32. I think it's the teacher's fault, actually. I think it's re-emphasised a conversation I had with yourself, actually, er, just before the Ofsted, where you talked about plenaries, you wouldn't go to court, and sit through an hour of, hours and hours, and the suddenly the judge doesn't make a judgement at the end, I mean, you know, these's got to be closure I suppose the terminology, (yeah, yeah) and after that conversation with yourself, actually, I've made a point of, of refocusing the plenary is probably actually key to the whole lesson. It covers the whole idea of, rather than focusing on the aims of the lesson, focusing on the outcomes, and the plenary is where you pull the outcomes together.

33. *Yeah, yeah, excellent. Um….How, how do you think your, your colleagues in the, in the department have reacted to the Strategy? Er…I'm really trying to delve into their kind of…their psychological response to it, rather than, than the mechanistic, you know, that they've adopted x, y and z strategy. I mean, how do they feel about the Strategy existing, you know, you know, someone coming along and saying "Hey, you know, you need, you need to have a think about how you teach."*

34. Interesting. That's a very good question actually. Um, the, the, all my staff basically, I mean V*** and K*** basically, um, have only been out of Teacher Training three years, so actually a lot of the things we've been spouting on the Key Stage 3 Strategy, they, they were doing on their inci…on their teacher training, so I suppose psychologically you're thinking well this isn't anything new, we do this anyway, I suppose, is one way of looking at it (sure) (unintelligible mumble) With the other cases, if you're teaching, its very much this is a new focus, and I found it very welcome, welcome in that respect. So I think in terms of the staff, er, the two I've mentioned already, K*** and V****, it was, you know, it's nothing new, we've already done this, we've been trained to do this, so let's just catch, so the psychological effort is too much impact. I think, I think when we were dealing with T***M***, a Zimbabwean, actually, psychologically, I think it's very different from anything he's experienced before, we made sure there's a support package in place, err, to help him support, we got KC involved to help him in terms of the, the process, psychologically he, he probably found it quite daunting. D***W*** on the other hand, err, from New Zealand, it's…er, I think he's found it daunting, but quite an experienced guy, but..not willing to completely embrace the process we enter. You know, everyone has different motivators, um, and D** is very much "Right, well, I'm only doing this for a year, anyway, so I'll just, you know, I'll just go through the process", so psychologically I don't think he's fully embraced the processes of it, and it's interesting if you walk into some of his lessons, he's still teaching the same way now as he was on day one when we had some concer…, you know we've had lots of consultancy in the mean time, so very, very much lip service in some cases, because people have different motivators. (yeah, yeah) Does this answer the question you're..

35. *Yeah, Yeah. I mean, so generally speaking, er, to kind of summarise, the ones who have been recently trained feel that it's no great shakes, it, it, it's you know*

36. Reconfirms, rekindles, what they are already doing, confirms that what they are doing is right. For me, for me, because I'm totally immersed in teaching, it was good for me

because it made me refocus and energise what I was doing. Er, and then for teachers from…Zimbabwe for instance, where they have a different ethos in education, or whatever, I, I think it was quite daunting to start with, although that said then, with the support in place, there has been a definite uptake, you know, improvement in terms of delivery. For people with different motivation or whatever in teaching, it's very easy to pay lip service and actually makes no change at all.

37. *Um, mmm, that's, that's the hard thing, always, with anything like this, getting it embedded, you know, getting it to be just a cultural change, you know, that, that, for everyone to buy into, this is how we do it.*

38. Well on one hand, you see, on one level, the individuals are saying, had bought into it, great idea, brilliant, excellent, but when it comes down to fly on the wall stuff, popping into lessons, stuff like that, actually very little, I would say,'s changed.

39. *Yeah, Yeah. I think, I think that the Strategy would find that, not surprising, but nevertheless worrying, you know, that a lot of input, and um, people saying yes, you know, to some extent giving lip-service to it, saying yep, yep, certainly agree with this.*

40. I agree with it at the school down the road, but at my school, I know the kids, I'll teach them the same way I've been doing for twenty years (yeah, yeah)

41. *Or even people saying yeah, I agree with it, I want to do this, but when we actually look at the lesson, go into the lesson, OK, let's see what's happening here, and it's the same-old, same-old. That's, that's the concern, I guess. I feel schools have moved, but the Strategy wanted to make a huge jump, and schools have made a smaller jump.*

42. Relatively. But again it's one of those things. You embrace it, it can be quite invigorating, quite (unintelligible), but it's like anything, it's, it's, it's… what's that term, that theory, that theory, whatever that whatever, you know, umm, the organisations that start out first of all and do all the, um, what's it called, preliminary, the groundwork, they always get exceptional results but when you start rolling it out for everyone else, you're fighting a lot of hard-core resistance, so even a smaller change is still a big change for ones who embrace it.

43. *Yeah, yeah. What do you…Do you think the pupils would notice anything if you, you actually took a Year Nine child and said "Well OK, how do you feel that lessons have changed since you arrived in the school in Year Seven?"– that would be pre-Strategy – "Have you noticed any change in lessons?" Do you think that they would be able to pinpoint anything that is different?*

44. Over the last three years….

45. *Maybe, perhaps in terms of, you know, the enjoyment, motivation that they have, teacher interaction, anything like that, would they, would they say "Oh yes, lessons have really changed" or would they not, not be able to identify any change?*

46. I think they would, I think they would, actually. Not some of them but I think they would. We've embraced the National Curriculum from day one, um, therefore we've always been delivering the National Curriculum, er, but from day one we began evolving and developing our own resources and stuff like that, and the whole focus has been on as much hands-on as possible, whatever, and the whole Key Stage 3 Strategy came along and the focus is three-part lessons…I think the students have probably grown as the department has grown as well, in terms of, of what they are

doing, how they are doing it, so I think they would notice there was a change, Whether it was because of the National…whether it was because of the Key Stage 3 Strategy or that we as a young, new department were evolving and developing as well, I think it would be difficult to distinguish between the two. Just trying to think of one or two, any specifics. I think they would notice there is a change in terms of a lot of the time, or some of the time I suppose, there is now the emphasis on the three-part lesson and a bit more structure, er, than there would have been three years ago. Even three years ago we were saying, look, make sure you are sharing your objectives of what you are doing with your students, erm, I think might be some, some change, I wouldn't think it was major. In terms of their enthusiasm for what they are doing, the biggest thing that's helped us, is fighting for more curriculum time, to do curriculum coverage. Er, when I started here we had a , sort of, three, four, four model, three in Year Seven, four and four, took two years to get a four, four, four model, which is not going to have an impact for another two years. By having more time we've implemented stuff like CASE, which we, we, we think will have an impact, so it's, it's ,having the time to deliver the curriculum the way I think it was meant to be, which is very much hands-on, practical. There's a lot of content, and unless you've got the time to deliver it, you're delivering the content, and not the fun bits of it.

47. *Mmm. Mmm. Actually that's right….Actually I'm just sort of, ummm…*

48. But, but I must just say the, the thing is though, because of the emphasis on, on the Strategy, on the core subjects, I've used it as a, as a, I won't say rod to hit the SMT with, but I've used it in terms of the, the importance as a core subject, to get extra curriculum time. (mmm, mmm) So it's a useful tool to get extra curriculum time.

49. *Mmmm. Mm, that's understandable. I'm sort of intrigued, really, umm, the Strategy was built on four, kind of, great premises, and one of them was there should be more, er, engagement, you know, the pupils should have more interaction, and in some other schools I've looked at, that interaction didn't really happen, lessons were very didactic, and the children in that..those schools have really picked up a big change. You know, perhaps, it may be, that because this school already taught along those lines, that, there isn't such an obvious change in what the pupils see, happening in lessons. You know, you know, in other words, because H***** was already moving along in that direction, then there wasn't the same kind of…*

50. Well also, if all of the staff have already been trained in the, the sort of theory of the Key Stage 3 Strategy anyway, we're already starting ahead of a lot of people that it was totally new to.

51. *Mmm. Were there any…What about some of the things that have come out from the Strategy, like, um, you know, more use of ICT, those little interactive whiteboards, you know, those sorts of things, has that, has that, sort of, taken off in the school?*

52. They have, across the school, they have. Not so much the whiteboard things, we were given some for science, and keep saying we'll get some, but haven't, but the thing is what, what they've done is, umm, …….ummm……..the Traffic Lights (yeah, yeah) are now an integral part of the plan, (sure) which people will use, but it's like anything, a good thing can be milked to death until, you know, it becomes pretty boring and (absolutely) and whatever, so it's a matter of balance. Some of the good things to come from the Key Stage 3 Strategy, is because of the focus on starters and and…..puddings…as everyone calls them actually, is, is that, that we're making specific resources, and there's resources come from the Strategy, I know A**** and K***** were, were, very good at, you know, with some starter activities, that we've now got followed up and they're now in the schemes of work. And that actually does

help, also with some of the books that have come out, you know, the starter activities, the Concept Cartoons, the, you know, the only problem you've got is these activities have got to be short and sharp because otherwise the starter takes over the whole of the lesson. So, the, the, some of the resources that came out were actually very, very helpful. I, I also think the consultancy time was helpful, as long as the right person is…. isn't critical, comes in, wants to work in partnership, but not create work, umm, and you know, we were very fortunate with K****, in terms of she came along, worked very well with V*****, helping and supporting her taking over Key Stage 3 stuff, she's worked closely with, with, um, new members of the department, you know, doing team teaching, discussing things, and also helping with the Booster lessons, which is another response that came out through the Key Stage 3 Strategy. Er, Booster lessons themselves, last year we used them quite a lot, where I emphasised for everyone to do them. This time we basically said they're there, we basically made up all the trays, it's up to you whether you want to dip into them, or not, because there's eighteen or twenty of them, whatever, that's a lot of work to do (sure, sure) so people dipped into them as and when they needed to. They also found the CASE, the computer CASE for Year Nine was very useful for, for, for that, which is similarly full of ideas.

53. *Now, it's interesting, and some, something we, we could consider here, is that, is that you've adopted a fairly, kind of, laissez faire approach, saying that, as regards the CASE, as regards the Boosters, individual teachers can dip into those, you know, and that's obviously one way forward. Another way forward would be to be, you know, much more, kinda, dictatorial, and say you must do these, and so on. Do you feel that giving the teachers that, that freedom, um, is, is, has been effective, I mean do you, do you sometimes sit back, I guess I'm saying, do you sometimes sit back and think "Goodness, perhaps the teachers aren't using enough of those Booster lessons. You know, may, maybe they should be using more?".*

54. My view of this is very simple. At the end of the day we are all professionals. I'm interested in outcomes, results. At the beginning of each year I produce a sheet for each year-group saying I expect group 1 to get these results, minimum, group 2 group 3 group 4, share it with all the department, actually, throughout the year we're looking at results, and the assessment of learning, so to speak, I found that very useful, because ultimately…and also profiling students with those graphs you gave me, taken the sort of next stage on, you might say, they've been very useful, because they make staff focus on the individual student in terms of their attainment, where they are and where they need to go to. We've also, in Year Nine this year, we've reorgan…we took a bold decision, to reorganise the whole, whole year-group so they can really targeted learning. Coming back to the original question, in terms of laissez faire, in terms of freedom of action, working in partnership with the team, I know how they operate, and you know, two things. One is the second in department, the Key Stage 3 Strategy, a lot of it is down to her, but my view is, we've gone through the cycle for tutoring now, with the, um, the, er, Booster lessons, CASE, we're, this is our first year for doing CASE, for me its giving the resources to the teachers, to deliver what they've got to deliver. You know we are prescriptive in terms of you know, over this four week period you do this module, this one this one, but that's more of an admin issue because of resources. (sure). Um, how they deliver the curriculum within that timeframe, frankly it's up to them to deliver it. If they think the most effective thing, way of delivering a part of the curriculum is standing on the field for a week, then I'd support them in that, if they can convince me that's the right thing. But I, I think you can get too prescriptive about you will deliver this objective by this time, in this way, and that's why I think the outcomes are more important than, than – the objectives are important, but the outcomes…

55. *Sure, sure, excellent. Are there any things, any other aspects of the Strategy – this is a kind of rounding off question – are there any other aspects of the Strategy that we haven't talked about, that you think are significant?*

56. ICT in science (right). Really, really, I'm totally focused, The way ahead in science is ICT in science. Now, from what I gather, I don't know very much about it, there is a strand which is ICT in science, that schools can have bought into….

57. *Right, now, yeah ICTAC. ICT across the curriculum, ICTAC. Yeah…*

58. Now we've heard nothing about it. The only thing I've heard, I did a course eighteen months ago, some material, some initial material was being, it was the, it was the…the, some of the… what was that initiative? Delivered for all teachers…(yeah) …whatever it was, anyway it was the launch….(it was NOF) Yeah, NOF funds, training. The whole idea it would be science focused, totally welcome that, because the NOF stuff was too simplistic, we need more stuff that's more focused on science, and I read bits about this, whatever they call it, ICT across the curriculum, very science focused, and I think the mistake they've made is to let schools buy into it or not buy into it,

59. *Yeah, the interesting thing, well ju – um, just to let you know, the ICTAC materials, um, er, two copies of big portfolios coming into each school, and each of these things contains ten booklets…… [long explanation of the arrangements and opportunities for the school]*

60. I think the Key Stage 3 Strategy could start losing its way, because it's, you could say, it's achieving a lot of the things it's put in place. I think there needs to be a re-emphasis of using ICT to enhance the curriculum. But again I would like to see it, because I can use that as a rod, I can go to my senior management and say I need investment in science, so I think that emphasis is fine. Carry on with the support of staff, but you could actually argue that maybe, that, here for example they are now doing a thing called Lead Learners where they are identifying four people to look at accelerated learning techniques. It's basically KS3 Strategy development, so maybe it needs to move to a more cross-curricular teaching, rather than the content, they're moving to ICT in……But the other thing that I think is a unique opportunity in Key Stage 3 in the next phase, the Key Stage 4 Strategy, and science at the moment is in the wilderness of where is it going until the 21st Century Curriculum comes in, and I actually look at that as a fantastic opportunity for the KS3 consultants to roll on up to KS4. Especially with the Applied Science part of it, total ignorance about it, there's a lack of resources for it, um, I think there's a real need for the KS3 to evolve into the KS4. I think it's the ideal time.

61. *Yeah, yeah. Well that's the plan, as of next Easter, it will cease to be the KS3 Strategy, it will be the Secondary….*

62. Like the Primary Strategy.

63. *Right, brilliant, OK, we have covered all the things here. It just leaves for me to thank you for your time.*

64. No, no anytime Chris….

65. *And I'll just spend the next two weeks typing this up!* (both laugh)

66. [Session ends. Continues as informal discussion of various research activities.]

Appendix 5.

Completed Questionnaire (Y7 student)

Four page (folded A3 sheet, double-sided) administered to Y7 student as part of the main research block. This is the first script from the data collection, included to illustrate the questionnaire style.

Similar questionnaires were used for Year 9 and Year 11.

Note that in Question 6, the student has added an additional box in order to include a subject of her choice.

7P.

1

Research Questionnaire (Year 7 pupils)

V1.4 Spring 2008

This questionnaire is part of a confidential and anonymous research programme to investigate the teaching of science in Key Stage 3. Your individual answers are private, and will not be shared with your school.

Do not write your name on this sheet. Do not worry about the little numbers on the sheets, they are for analysing the results of the survey.

1. Are you a boy ☐ 1 or a girl ☑ 2

2. Which primary school did you attend? St Mary's Cof school 3

3. How did you feel about the science that you did at your primary school? Circle one:

Enjoyed it a lot 4 | [✓ Quite good 5] | It was OK 6 | Didn't like it 7 | Hated science 8

4. How do you feel about science now, at your secondary school? Circle one:

Enjoy it a lot 9 | Quite good 10 | [✓ It is OK 11] | Don't like it 12 | Hate science 13

5. How good do <u>YOU</u> think you are at science? Circle one answer:

[✓ Really good 14] | Quite good 15 | About average 16 | Below average 17 | Not very good at all 18

6. Here are some school subjects. Write number 1 against your favourite, write number 2 against the next best, and so on.

English	6	19
Maths	8	20
Science	7	21
Geography	9	22
History	10	23
PE	5	24
Technology	3	25
Music	2	26
Art	4	27
Languages	11	28
Drama	11	

Your science lessons now.

7. Do your science lessons start with a quick activity to get you thinking about the subject or about things that you did last lesson?

Yes ☐ 29 No ☑ 30

8. Do you find it easy to remember what you did last time, and 'get into' thinking about science at the start of the lesson?

Yes ☐ 31 No ☑ 32

9. What do you think is the best way to start a science lesson? Tick **two** answers:

Write down the aims of the lesson	☐	33
Teacher explains the lesson	☐	34
A class discussion of the topic	✓	35
Go over what we did last lesson	☐	36
Reading some information	☐	37
A quick activity to get me thinking	✓	38
An idea of my own (explain in this space):	☐	39

10. At the end of each lesson, do you have a chance to think about what you have learnt during the lesson?

Yes ☐ 40 No ☑ 41

11. How does your lesson end? Tick the **two** most common things that happen:

We just stop work, pack up and leave	✓	42
Teacher talks about the lesson	☐	43
A class discussion of what we did during the lesson	☐	44
Teacher sets the homework	✓	45
Talk in groups about the work	☐	46
We all start chatting until the bell goes	☐	47
This is what happens:	☐	48

Half way. Well done. Here is a joke for you:

Have you heard about the cross-eyed teacher? He couldn't control his pupils!!

12. How often do you do practical work in your science lessons?

Nearly every lesson		49
Most weeks	✓	50
Every few weeks		51
Not very often		52
Hardly ever		53
Never at all		54

13. Which of these things have you used this year in your SCIENCE lessons? Tick as many as you need to:

Computers in the lab		55
Computers in a different room in school		56
The internet at school		57
The internet at home for research	✓	58
Computer at home for doing homework	✓	59
Little individual whiteboards in class		60
Computer projector in the lab	✓	61

Getting ready for your exams.

14. How ready do you feel for the school science exams? Circle one answer:

I'm really confident	Generally feel fine	[✓ Well, OK, I guess…]	A bit worried	Really scared	I don't care
62	63	64	65	66	67

15. Which of these things have you used to get ready for exams? (You can tick several)

Extra lessons		68
Revision guides (books)		69
Revision in class	✓	70
Revision programmes on video		71
Revision homeworks	✓	72
Revising from my exercise book	✓	73
Something else (explain in this space below):		74

Knowing how well you have done in science

16. How well do science teachers seem to know how well you are getting on? Circle a number:

They know me well ⟷ They have no idea

1	2	[✓ 3]	4	5	6
75	76	77	78	79	80

17. Have you been told your target grade for the SATs exams in Year 9?

Yes ☑ 81 No ☐ 82

18. When your work is marked, does it have: (You can tick as many as you like)

A mark out of 10 or 20, etc.	☐	83
A national curriculum grade	☐	84
A helpful comment	☑	85
Writing about what I did wrong	☐	86
Lots of ticks, not much else	☑	87
My book doesn't get marked	☐	88
Something else (explain in the space below):	☐	89

Starting science at secondary school

19. When you first started in Year 7, how did you feel about science at this school? For example, were you worried, excited, bored, interested, or what??

I was bored in one of the lessons but in one I was interested

90 – 95

20. When you think about the science that you have done so far in Year 7, how much of it had you done already in primary school? Circle one answer:

Most of it	Quite a lot	[✓ Some bits of it]	Not much	None of it
96	97	98	99	100

Phew! Well done. And thank you for your help. Can you just go back and check that you have answered all of the questions? That would be REALLY helpful!

Another joke; Why do all of your teachers wear sunglasses?
Because the kids are just <u>too</u> bright!