Student experience of school science and its relationship to post-16 science take-up

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Submitted in accordance with the requirements for the degree of
Doctor of Philosophy

The University of Leeds, School of Education

August 2013

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

Acknowledgements

I am deeply grateful to the teachers and students of the research study schools who all contributed equally to this research. Thank you for letting me hear your voice and report it in this thesis.

Heartfelt thanks to Professor Jim Donnelly and Dr Stuart Bevins who believed in my capability and spent their valuable time looking at drafts of material. Your advice and support is much appreciated. Special thanks to Matt Homer who helped make sense of the data.

Thank you to family and friends for your support – it made the journey easier.

I am grateful for the funding provided by the White Rose project.

Abstract

This study investigated the experience of school science and its relationship to take-up of science amongst post-16 students in England. The empirical work was based on a two-phased mixed methods approach. The first phase consisted of survey questionnaires involving the 'storyline' method in which students in Year 12 (ages 16-17) indicated the high and low points of their experience of school science covering Years 6 - 11. They were also asked to complete survey items to explain the factors that influenced their decisions to take science or not post-16. The second phase consisted of interviews of a sample of surveyed students in which they detailed aspects of their school science experiences and decisions to take science or not after GCSE.

The results showed that the average pattern of graph trajectory became increasingly positive for scientists while the pattern for non-scientists remained the same as slightly positive throughout their years in secondary school. Students in this study tended to make their science choices later in Year 11. Three main factors - interest in school science, success in science and the utility value of science (mainly for careers) mediate a network of influences that includes experience of school science and these drive the decision to take up science or not.

The main conclusion is that school experience of science does play a role in post-16 science take-up. Science choice is based on a rational model of decision making in which interest, success and value of science are the key factors determining the outcome. This has implications for practice suggesting that uptake of science can be increased by improving the quality of student school experience of school science.

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List of abbreviations

A level	Advanced level
BERA	British Educational Research Association
DfES	Department for Education and Skills
DCSF	Department for Children, Schools and Families
DfE	Department for Education
EVT	Expectancy-Value Theory
FSM	Free School Meals
GCSE	General Certificate of Secondary Education
ISV	Interest-Success-Value
NFER	National Foundation for Educational Research
NPD	National Pupil Database
OFSTED	Office for Standards in Education
P	Progressive (trajectory)
PISA	Programme for International Student Assessment
PUD	Progressive with ups and downs (trajectory)
QCA	Qualifications and Curriculum Authority
R	Regressive (trajectory)
S	Stable (trajectory)
SES	Socioeconomic status
STEM	Science, Technology, Engineering and Mathematics
STEMNET	Science, Technology, Engineering and Mathematics Network
TBP	Theory of Planned Behaviour
TIMSS	Trends in International Mathematics and Science Study
UCAS	University and Colleges Admissions Service

Chapter 1 Introduction

Science is not for me…

Louisa is an extremely gifted student who excelled in all her subjects and gained 11 A* grades in her General Certificate of Secondary Education (GCSE) examinations. As her science teacher, I was surprised when she chose not to take science any further as she had appeared interested and engaged in it. When asked about her decision, Louisa gave the response above. Later, when embarking on the PhD, this incident was recalled when reading research about the reasons why students choose certain subjects and career paths. The aim of this thesis is to explore how school experience might contribute to this very personal judgement.

A number of researchers have taken different perspectives to explain how students track along different subject and career paths. Some research concentrates on organisational structure (e.g., Smyth and Hannan 2006) and on the characteristics of the individual (e.g., Kroger 2007). Some studies focus on science outside of school (e.g. Haste 2004) as a reason for the decreasing interest in aspects of school science. Others (e.g. Osborne, Simon and Collins 2003) focus on student experience of the science curriculum and how it is taught as a reason for the lack of interest in science. Still others (Schreiner and Sjöberg 2007) focus on identity construction as the key factor to being a scientist or not. However, few studies have attempted to take account of the broad variety of ways, formal and informal, in which schools can constrain or facilitate particular subject choices particularly in the English context[1]. This gap in knowledge led to the main focus of the study to look at school experiences. It was decided to focus attention on school influences from the student perspective rather than approach the study by looking at school policies and practices using a top-down methodology. Since the study involved the student experiences, it was essential to have students describe their experiences of school science in their own voice.

[1] Smyth and Hannan's (2006) study was carried out in Northern Ireland.

This thesis is an attempt to understand how young people's experiences of school science in the English school system influence their decisions to take science or not. It is acknowledged that this is not a straightforward task. There are a number of other influences that may affect decisions to take science and that there will be a variety of ways that students choose to take science or not because of the interaction of all or some of these influences. Apart from these influences, the individual and social characteristics of the student contribute to the complex network of relationships between school experience of science and the decision to take science. This study concentrates on a small aspect of a broader issue and it is hoped that the new knowledge from this study will enrich understanding of the other perspectives.

1.1 Rationale

In recent years, there has been an increasing interest in the reasons that students choose to take science. This interest stems from a concern over declining participation rates of students in the science subjects, particularly physics (e.g. Gill and Bell 2011). The phenomenon of low participation is not just limited to the UK but also found in the USA (e.g. US Department of Education 2006), Australia (Lyons and Quinn 2010) India (Garg and Gupta 2003) and even Japan (Ogawa and Shimode 2004). However, more recent studies noting the shifting patterns of A-level entries in science subjects state that it is more an irregular plateau (Donnelly and Ryder 2011) or a stagnation rather than a decline (Smith 2010). The figure below indicates the current situation as a small increase in numbers of students taking science subjects at A-level (see Appendix N). The rationale underlying this study, therefore, is not that there is a shortage of scientists but that in relation to growing numbers of students completing their A-levels year upon year, the relative numbers of students completing A-levels in science subjects has not increased in proportion.

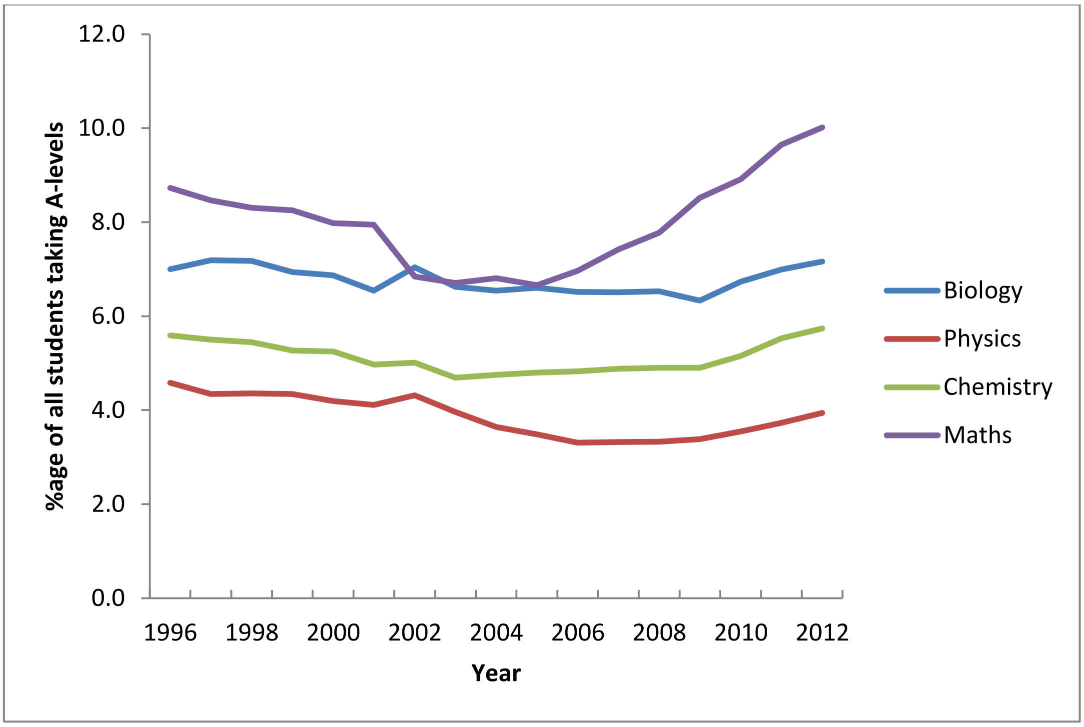

Figure 1.1 The percentage of students taking A-level subjects between 1996-2012 (source: DfE 2013)

There has been an increased interest in researching the phenomena of students' choice to study science or not (e.g., Lindahl 2007); perhaps as a reaction to the perceived decline in numbers of students taking science. The initiatives and policies aimed to increase or widen participation in science in response to the earlier findings of declining participation in science appear to have limited impact (Smith 2010) on enrolment numbers.When comparing these recent findings on attitudes to science with those from a century ago (e.g. Lewis 1913), it is seen that many generations of students have emphasised the same reasons for feeling disengaged from science. One reason may be the interesting aspect to emerge from two different large-scale international studies (TIMSS[2] and PISA[3]) which show that students in technologically advanced countries believe science to have little importance in their lives. Various smaller studies (e.g. Jenkins and Nelson 2005, Haste 2004) also find that although many students believe science is an important subject; it is not one that is important to them personally or one that they would want to take up further as a career.

[2] Trends in International Mathematics and Science Study

[3] Programme for International Student Assessment

This suggests that rather than concentrating on bigger and better initiatives to engage students, it is important to look at influences closer to home in an effort to understand why students should feel that science is 'not for them'. One such influence is school where children spend as much as 15,000 hours during which schools and teachers have an impact on children's development (Rutter, Maughan, Mortimore and Ouston 1979). The role of institutional experience of science is also highlighted by Seymour and Hewitt's study (1997) in which they claim that the problems arising from the structure of the educational experience of science make a much greater contribution to student attrition than the individual inadequacies of students or the appeal of other subjects. Although their study was based on attrition of science students in college in the US, it highlights importance of institutional experience of science that informs the current study. Therefore, in looking at influences closer to home this study looks at the way schools play a role in student experiences of science.

1.2 Research aims and objectives

The research focus emerges from the observation that students in England spend almost 1000 hours[4] in science classes during their secondary schooling and it is my belief that this experience will have some influence on students' perceptions of school science. It is intended to examine students' experiences of school science for evidence of its influence on students and to understand how these experiences may impact on student choice to take science or not after GCSE. Thus, the main aim of the thesis is stated as:

To examine student experience of school science and its relationship to post-16 science take-up.

The following three objectives for undertaking this research represent the gaps in the research of post-16 take-up of science and are areas to which this thesis will contribute.

1. To listen to the student voice about their informal experiences of school science using a novel method of collecting data about school experiences

[4] Based on five hours of science lessons per week taught in most English secondary schools

2. To add to the few research studies that examine students' experiences of school science in the English context and to contribute to the growing number of studies that examine influences on the decisions to take science or not
3. To examine the relationship between school science experience and take-up of science and to gain insight into why some students with similar experiences choose to carry on with science while others do not

Any study purporting to look at student experiences should involve the student voice to explore their views about their experiences and how they see their world. Although data generated by such studies present problems of interpretation (Jenkins & Pell 2006:16), the findings can still present significant insight into how students experience school science.

Above it is mentioned that student experiences of school science is a less well-researched field; the main studies are Lindahl's (2007) longitudinal study of Swedish student experiences and Lyons' (2006) study of Australian student experiences of science. Although Osborne and Collins (2001) and Cleaves (2005) present an English context of students' experiences of school, this has not been the main focus of their respective studies.

Of the more recent studies available on subject choice, there are a range of foci including effects of school ethos and management (Smyth and Hannan 2006), individual aspects such as self-efficacy (Lindhal 2007), wider social aspects such as cultural capital (Archer 2003b) and socioeconomic status (Gorard and See 2009). However there are still gaps in the research on choice of subject (Wright 2005:38). Not a great deal has been written about the role that school experiences play in decision to take science; most likely because research has been concerned with individual factors that motivate students to take science such as self-efficacy and identity. In this study, the approach will be to use the students' own judgment of their experiences and to look for its relationship with post-16 science take-up, focussing on how school experiences have played a role in their choice to take up science or not.

Finally, gaining insight into the phenomena of school science experience and why some students decide to carry on with science while others don't will help us to better understand how schools can identify potential problems and help address students' current perceptions of science.

Keeping in mind the research objectives and in trying to address the aim of the study, the following three research questions have been developed after a review of research in this field:

RQ1: What are students' perceptions about their school science experience?

RQ2 What are the reasons students give for deciding to study or not to study science post-16?

RQ3 What role does school science experience play in student decisions to study or not study science?

The purpose of this study is not to report results of an opinion poll among students or to report the order of the most important influences on students' choice to take science or not in the future. Rather, the results from the study are to be used as a framework to understand how students perceive school science and how school science experience plays a role in student decision-making to take science or not post-16.

1.3 School experiences of science: defining the focus of the thesis

In this section, some of the concepts related to science education and which form a part of the current study are defined to help understand the position taken by the researcher.

Understanding how school experience contributes to subsequent science choice is an important facet of subject choice in general; therefore, in this study, students views of school science in each year at school is quantified on a scale similar to attitudinal scales[5] meaning that students can have a negative or a positive perception of school science.

[5] Having two opposite directions, negative to positive.

1.3.1 Defining school science

The term 'school science' as it is used in this current study means the subject that is taught in both key stages at school. It includes the science curriculum that is taught in the science classroom as well as the activities associated with school science such as practical experiments, group activities, reading science text-books or copying notes from the board.

In Key Stage 3 (KS3), science usually means a combination of chemistry, physics and biology; while in Key Stage 4 (KS4) the term school science has more complex meaning as students study different subjects in science in variable ratios according to the GCSE qualification they are taking. Before 2008, most KS3 students studied all three sciences together and know this subject as 'science' rather than by the three individual subject names. However, with the removal of KS3 Science SATs in 2008, most schools have chosen to fill the void created by introducing the two-year GCSE course a year earlier; effectively creating a 'three-year' GCSE. Because of this, students will be familiar with the three separate components of science – physics, chemistry and biology if they are on a Triple science pathway. For students on a Dual Award science pathway, they take Core science and Additional or Applied science; these qualifications consist of all three science subjects. These students may not be able to distinguish between the three science subjects and just call them 'Core' or 'Additional'. For this reason, the use of the term 'science' in this study encompasses all three sciences as this is the guise with which most students will be familiar. For some students, science is the subject they will be taught until the end of GCSE and they will only encounter the separate sciences (biology, chemistry and physics) at Advanced level (A-level). Therefore, it is highly likely that most students in this study think of school science as an amalgamation of the three separate sciences.

An assumption in this study is that the students do not have a uniform preference for all three science subjects. This assumption is based on personal experience where students prefer one science subject over others; however, it is acknowledged that the preference for different subjects arises once the distinction between the three sciences has become clear, usually later in the school (Years 10-11). In the lower secondary school years, science is not usually taught as three separate subjects and students are more familiar with science as a single subject.

1.3.2 Current models of the choice process

There are a number of different models used by researchers to explain patterns of decision making and choice for future careers. Some studies follow a rational choice model that asserts individuals make rational decisions about their subjects based on the options available to them and the value of the options for their future (e.g. Coleman 1990, Symonds 2007). Other researchers have adapted this model to take into account perceptions of opportunity and individual personality. For example, Foskett and Hemsley-Brown (2001) recognise that choices are the outcome of a rational process that does not take place in isolation but are rooted in identity and perceptions of the subject. They call this pragmatic rationality model since individuals take into account realistic factors that inform their choice. Some models of choice suggest future relevance, interest and academic self-efficacy are dominating factors in choice (e.g. Pike & Dunne 2010). These models are based on the expectancy-value theory developed by Jacqueline Eccles and her colleagues (1983). They take into account the role of value and the expectancy of doing well in a task when making a choice. In all of these models, it is seen that individuals make subject choices themselves without outside agency. However there are several studies (e.g. Ryrie, Furst and Lauder 1979, Davies *et al* 2004) that point out choice to be influenced by economic, cultural or institutional constraints. These structuralist models take into account institutional as well as personal factors that influence choice. For example, the social cognitive career theory proposed by Lent, Brown and Hackett (1994) focuses on several variables that interact with other aspects of the individual and their environment to help shape the course of career development. The authors argue that personal variables such as self-efficacy and personal goals enable individuals to exercise agency within their own career development and additional sets of variables such as physical attributes (e.g. race, gender), particular learning experiences and features of the environment (e.g. social supports, barriers) influence career-related interests and choice behaviour.

Although these models are based on student career decisions and not on science choice, since there is a paucity of well-documented models of the science choice process, these help inform the explorative approach of the current research. This explorative perspective will help understand the way that students are influenced in their choice to take science or not.

1.3.3 Perceptions, views and experience of school science

In the context of this study, both perceptions of school science and views[6] of school science are defined to be the thoughts, beliefs and feelings about the learning of school science. Therefore both terms will be used synonymously throughout the thesis. But, student perceptions are regarded as different from student experiences because experience of school science has a nuanced meaning in terms of perceptions of school science. Students are active processors of information rather than passive recipients of knowledge; perceptions are influenced by personal attributes and situational cues (Schunk, 1992:3). Since the school is a social world, there is a complex relationship between intrapersonal influences (such as the self) and extra-personal influences such as other people. Students' perceptions may be formed unconsciously through a number of influences such as schools, media, parents and peers as well as the image of science in the real world and scientists. Experience of school science is just a description of the lived event of daily school and classroom processes. Therefore it is claimed here that perceptions of school science are affected by school experience; for example a teacher's teaching can be experienced by a student as an event that occurs in a classroom setting. However, the perception of a teacher's teaching – whether good or bad - can only occur when there is experience of teaching to enable a comparison to be made. Not only this, but the perception is also shaped by individual attributes as well as being shaped by the wider social environment. For example, the perception of classroom environment of a low ability student is different from that of a high ability student because of a number of factors such as ability, relationship with teacher, relationship with peers and the course content being studied. The experience of either student is similar but their perceptions may negative or positive dependent upon these factors.

[6] And in some places, opinions.

In this study, the aim is to examine student views (or perceptions) of their experiences of school science to enable further examination of the possible role that this perception of their experience may play in their decision to take science or not after GCSE.

1.4 Terminology

Since this section deals with decisions to take science, the natural grouping of students is to divide them into:

1. Science students /scientists – the students that have chosen to take at least one science A-level after GCSE.
2. Non-science students / non-scientists – the students that have chosen not to take any science A-levels after GCSE.

The term science A-levels will be used to replace the use of A-level biology, A-level chemistry and A-level physics. Where the need to specify which particular science A-level a student has chosen, this will be clarified in the relevant place.

Other terms and notations used in this study will be explained and exemplified when they are introduced in the relevant sections.

1.5 Structure of the thesis

Chapter two is the main literature review; presenting past and current research into the various facets of school science experience and choice of subjects. In this chapter the structural, individual and social influences that affect a student's decision to take science or not post-16 are described and discussed.

Chapter three is a short chapter in which the research questions are justified. It acts as an epilogue to the main literature review which was presented in chapter two.

Chapter four is a description and justification of the research methodology. It also describes the limitations of the methods. A two phase mixed methods study was undertaken over thirty weeks in which survey forms were distributed to seven different schools, collected and analysed during phase one. In phase two, a selection of students at five of the seven schools surveyed were interviewed.

Chapter five presents the findings for research question one about students' experiences of school science. Four different trajectories of student experience are presented and there is a description of the high and low points of student experiences of school science.

Chapter six begins with a discussion about the time when students tend to make decisions to take science or not. It then paints a broad picture of the key factors that led students to take science or not post-16. The overlap of these key factors with the high and low points of school experience is discussed.

Chapter seven presents a model of the role of school experience of science on the decision to take science or not after GCSE. It offers a conceptual framework for understanding the role of school experience in students' choices at the end of KS4 based on three main factors – interest, success and value of science. The notion of resilience is introduced to help understand the pattern of school influences on students. In this chapter, student profiles are described in terms of the conceptual framework.

Chapter eight offers critical reflection and discussion of the findings and concludes the thesis by reflecting on the contribution of the study to wider research agendas, its limitations and possible avenues for further study.

Chapter 2: Literature review

2.1 Introduction

This chapter is a review of the literature on the different influences that impact on school science experience of students and the influences that effect students' decisions to take science post-16.

The review considers literature on student experiences of school science and choices to take science from 2000 onwards. Earlier work is also included where it is necessary to contextualise or define concepts or where the work is pioneering or the only of its kind.

The present review is structured around a categorisation of the various influences on school experience as well as on the choice to take science which have been generally identified in the literature:

—school influences

—individual influences

—social and cultural influences

—instrumental influences

2.2 School influences

Following Roberts review (2002) and other reports (e.g. Royal Society's *A degree of concern,* 2006b) which highlighted falling numbers of students taking chemistry and physics subjects, an important strand in research in this area focused on the reasons for students choices to take science (e.g. Vidal Rodeiro 2007, McCrone, Morris and Walker 2005, Lyons 2006). These studies conclude that there are many different factors that have an effect on science choices which has inspired further research into these influences and that are reviewed later in this chapter. Fewer research studies look at school factors that have an influence on science uptake or how school factors operate on the science choice process[7]. Since there is not much research on school factors and decision to take science, it is useful to consider studies that look at school factors influencing post-16 participation to draw useful parallels. One such study by

[7] Bennett, Lubben and Hampden Thompson (2011) is an example of these papers.

Foskett, Dyke and Maringe (2008) analyses data from focus group interviews of Year 10, 11 and 12 students from 20 different schools. Combining this with interviews of head teachers, heads of year and heads of careers in each school, the authors find that four key aspects of school influence post-16 participation in learning. These key aspects are: whether the school had a sixth form or not; the characteristics of school leadership, ethos and values; the socio-economic status (SES) of the schools' catchment; and the organisation and delivery of careers education and guidance at the school level. Their findings resonate with Bennett *et al* (2011) findings that the composition of student intake, the ethos of the school, school management, the science curriculum on offer and the career advice offered to students are the ways that different schools influence post 16 choices and decisions. Together these two studies provide a framework of school influences to conceptualise the school factors effecting choice of science and to a lesser extent, experience of school science. Of the four common influences[8] on school experience, school ethos, leadership and management are discussed in this section as they are school influences. The other two themes – SES and careers guidance are discussed in the relevant sections below.

2.2.1. School ethos, leadership and management

Foskett, Dyke and Maringe (2008) identify four distinct types of schools that have different impacts on the choices that students make in post-16 education. The typology arises from the subject choices offered, the schools' leadership views on careers guidance, whether or not the school has a sixth form and the differing emphases on examination results. Foskett *et al's* criteria indicate the ethos of the school is important while Bennett *et al* (2011) suggest another important contributory factor is selectivity in student intake. They find that selective schools have consistently high numbers of students who take up physics and chemistry.

In their seminal book *Fifteen Thousand Hours* (Rutter *et al* 1979) the authors highlight how school ethos or culture can influence students. The authors argue that schools have a particular set of values, attitudes and behaviours which become characteristic of the school and that these influence students' attitude to learning. This point concurs

[8] These are school leadership and management, school ethos, careers guidance available and composition of student intake.

with Foskett *et al* (2008) who further assert that different types of school influence students' attitudes to learning in different ways. An example is presented by Solvason (2005) who examines how the Specialist Status[9] of a school changes the funding allocation for a particular specialist subject and asserts that raising the profile of a subject in such a way increases participation of students. As an illustration, investment in science at a Science Specialist school provides for well-equipped laboratories and state-of- the-art resources as well as specialist teachers for each science subject. This raises the profile of science as a subject and may have a positive effect on student interest leading to subsequent take-up of science. The converse may also be true; in the case of a Humanities Specialism[10] school resources are used to raise achievement in those subjects (Solvason 2008) and this could be detrimental to the resources available for science, consequently affecting student interest in this subject. However, the dearth of evidence in the area means that one cannot generalise or make comparisons.

Some studies argue that institutional constraints limit the choice process; for example, Woods (1976) in his study of subject choices in secondary school concludes that the range of choice is variable for some students and non-existent for others. He contends that for most students subject choice has different meanings; the initiated[11] student generally makes a choice with view to job prospects and ability while the working-class student chooses the line of least resistance. His study suggests that the way a school manages subject options plays a critical role in the choices available to students highlighting the implicit role of school management. This point is picked up in a review of the literature by McCrone *et al* (2005) who claim that young peoples' choices appear to be prescribed by school policy leading them to have very little choice at all. This is further supported by the examination of school management in the Smyth and Hannan (2006) study of school effects on subject choice in Northern Ireland. They identify a number of school based influences on later subject choice, claiming that

[9] Specialist School status refers to an initiative introduced in 1994 in which schools were invited to apply for specialist status in a subject area that they deemed to be a strength and for which they would be awarded a capital grant as well as funding by the Department for Education & Skills (DfES).

[10] E.g., Languages, Art or Business

[11] Woods uses this term to describe generally middle-class pupils who are not estranged from school in general.

students' choices are already determined to a large extent by streaming policies and timing of subject choice. Streaming policies allow only high ability groups to take particular subjects and qualifications thereby restricting choice for less able students while the authors find that subject options forced earlier in lower school tend to favour science take-up.

2.2.2. Science curriculum

A considerable amount of literature spanning many decades highlights the impact of taught curriculum on students' decision to take science (Pritchard 1935, Gardner 1985, Woolnough 1994, Osborne and Collins 2001, Lyons 2006, Lindahl 2007, Lyons and Quinn 2010, Krapp and Prenzel 2011). From these studies two aspects of the curriculum emerge; one is the engagement of the curriculum in science and the other is the notion of the difficulty of the science curriculum. Both aspects are reviewed below.

2.2.2.1 Engagement of curriculum

In his five-year longitudinal study of 21 children's progress through learning science at school, Michael Reiss (2000) concludes that science curriculum needs to be reformed to be of more value to students. Similarly, in their review of students experiences and perspectives of the national curriculum, Lord and Jones (2006) note that students at secondary school 'do not easily see the relevance of the curriculum and of what they are learning to their daily or future lives' (p 29). Osborne and Collins (2001) find that students regard the science taught in schools to be overloaded with content and not generally relevant to working life; giving the sense that 'students were being frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt' (p450). The authors conclude that most students feel the curriculum is too rushed, leaving too little time for reflection. Similarly, in a unique study carried out by Cerini, Murray and Reiss (2004) the authors find that a significant majority of the respondents feel that the science curriculum is exam-led and full of facts that have to be learned.Such expositions have been carried out at a time when science curricula were widely criticised (e.g. Millar & Osborne 1998) for concentrating too much on the needs of future scientists at the expense of science that is relevant to students' everyday lives.

There is a dearth of more recent studies looking at student experience of the current science curriculum introduced in England in 2006. Although this gap is addressed by Ametller and Ryder (in press) who consider the impact of the latest science curriculum on school science experience of students; it is with a focus on impact of socio-scientific issues and the nature of science. The current thesis may provide some insight into student perceptions of the current science curriculum by analysing student comments about their experience of the current science curriculum.

The research evidence on curriculum content indicates that enjoyment or boredom with science is not the only factor arising as a consequence of curriculum effects. For example, in their questionnaire study of 317 Year 10 students asking about their interest in biology and physics, Williams *et al* (2003) find that most students' perceptions of science being boring is linked with their perception of science being difficult. This finding is resonated by Haynes in her report (2008) *Studying STEM[12]: What are the barriers?* She concludes that the science curriculum is perceived by students as boring and difficult. Similarly, Lyons (2006) looking at enrolment decisions of Australian high school students finds that to a large number of students, the curriculum content is boring, irrelevant and difficult. The aspect of difficulty of science is reviewed below.

2.2.2.2 Difficulty of science

In their review of studies on influences that affect science choice, Tripney *et al* (2010) find that difficulty of science is the main reason that students elect not to take STEM subjects after GCSE. An example of one such study is Osborne and Collins (2001) in which they explore student experience of the science curriculum carrying out focus group interviews of 144 students and finding that amongst both types of student – science and non-science, there is general agreement that many aspects of science are hard or difficult to understand.

There are two ways that difficulty in science is reported by students; one is actual difficulty arising from possible differences between science and non-science subjects

[12] Science, Technology, Engineering and Mathematics (STEM)

and the other is student perception of difficulty in science. Both of these are discussed in turn below.

The issue of science being a more difficult subject than others is not new; in 1974 Duckworth and Entwistle note that physics and chemistry are rated as the most difficult subjects compared to English and geography by secondary school students. However, there is a dearth of studies comparing the relative difficulty of subjects. But from findings of those studies that are available (e.g. Kelly 1975, Fitz-Gibbon and Vincent 1997, Coe 2008) there is a consistent pattern showing that STEM subjects are more severely graded than non-science subjects. For example, Coe *et al* (2008) in their report on relative difficulty of examinations in different subjects in the comparison between STEM and non-STEM subjects at A-level claim that STEM subjects are harder. At GCSE, they report that the difference between STEM and non-STEM subjects is less marked but there is still a tendency for STEM subjects to be the ones in which students are likely to get lower grades. This is in contrast to the investigations of subject comparability carried out by the QCA (2008) in which it is found that subjects were generally in line with each other. However, Coe *et al* (2008) point out that this conclusion is unmerited 'given the extent of the differences found and the cautions that surround the results' (p 61).

Looking now at the perception of difficulty in science; a number of studies (e.g. Kessels, Rau and Hannover 2006) find that students perceive science subjects to be more difficult in comparison to non-science subjects. Similarly, Coe *et al* (2008) contend that there is a widely held perception that science subjects and in particular physics, are more difficult than others. Amongst the reasons put forward by researchers is that a subject like physics is perceived as being chosen by students who do well (Cheng, Payne and Witherspoon 1995, Osborne *et al* 2003) and this reinforces the notion that these subjects are for the more intelligent students and will therefore be more difficult. This aspect of perception of difficulty overlaps with students' self-efficacy and is discussed in section 2.3.4 below.

2.2.3. Teacher influence

From their inspection of 45 schools in England, OFSTED in their *Guidance for Students Studying Science* (2010) note that students often cite good teaching as a factor that attracts them to science. This suggests that teacher influence is significant both as part of student experience of school science and as an influence on students' choice to take science or not, as well as one of the wider social and cultural variables acting on both. In this section, the effect of teacher quality and the effect of teaching methods are discussed as part of a teacher's influence on the students they teach.

2.2.3.1 Teacher quality

Existing research points to teacher influences such as feedback, expectations, and encouragement as having an impact on student attitude and interest as well as science career motivation (Urdan and Schoenfelder 2006; Rowe 2003; Hattie 2003; Logan and Skamp 2012). The availability of enthusiastic and well-qualified teachers has been identified, by various studies and reports, as one of the most effective factors that influence young peoples' perceptions of science (e.g. Munro and Elsom 2000, Osborne *et al* 2003, Hattie 2003, Rowe 2003, Bevins, Brodie and Thompson 2008, Wai Yung et al 2011). In an extensive study of 1180 A-level students and interviews with 84 members of staff at school, Woolnough (1994) finds that teachers have a strong influence on their students' enthusiasm for a subject, as well as directly influencing their achievements. Investigating the conception of good science teaching, Wai Yung *et al's* (2011) study of 4024 students and 110 teachers in Hong Kong identifies six dimensions. Of these six dimensions, both students and teachers identified that subject content knowledge of a teacher is just as important as the strategies they use for teaching. These findings suggest that teacher qualities influencing choice of a subject are not just teachers' subject knowledge and teaching style but also the teacher's enthusiasm that captures students' interest and motivates them to study a subject.

Although, being well-qualified is not synonymous with good teaching, Osborne *et al* (2003) and others (e.g., Hattie 2003) have shown, teacher subject knowledge is a determinant of effective teaching. Further evidence is provided by a NFER (2006) report finding that schools with lower than average GCSE results had higher proportions of the least qualified teachers. A shortage of specialist science teachers and difficulties in recruiting and retaining teachers have implications for science teaching and learning; for example, Springate, Harland, Lord and Wilkins' (2008) study finds that some of their interviewees decided not to continue with physics or chemistry because of poor, uninspiring or unhelpful teachers. Smithers and Robinson (2005) in their research examining teacher deployment and student outcomes in physics find that teachers' expertise in physics as measured by qualification is the second most powerful predictor of pupil achievement in GCSE and A-level physics after pupil ability. The report also claims that schools are using non-specialists or teachers of other subjects to make up for the shortfall of specialists. This may also have an influence on student attainment and subsequent choice of science.

With so many decades of research evidence of the influence of teachers on students' experience and choice of science, it is not surprising that there has been concern in England over shortages in teacher supply, and of problems recruiting and retaining teachers (DfES 2005; Bevins, Brodie and Brodie 2005; Barmby 2006). Although See, Gorard and White (2004) conclude that there is no special crisis in teacher supply and demand in England and Wales, their conclusions would have been more convincing if they had included evidence from the London region. Reports (e.g., DfES 2004) show that London experiences a greater shortage of teachers with greater teacher vacancy rates across secondary schools in comparison to national figures. Although recent government figures indicate that improvements are now being seen in teacher numbers (DfE 2011), the teacher vacancy rate is not comparable to previous years' rates as the statistical methods have now changed. An aspect related to teacher retention rates is that of teacher turnover; there are a number of studies that report the disruptive effects of teacher turnover on students (e.g., Ronfeldt, Loeb & Wyckoff 2013; Allen, Burgess and Mayo 2012). Archer (2003a; 65) illustrates the effect of teacher turnover on students by showing student's feel 'abandoned' by teachers as a result of high rates of turnover within their schools.

2.2.3.2 Teaching methods

In the section above, it is seen that specialist teachers have a positive influence on attainment of students in that subject. In recent years, there has been an increasing amount of literature on the ways that teachers influence attainment and interest in the classroom. Osborne and Collins (2001) claim a consensus amongst students that their interest is engaged and sustained by teachers who make lessons fun either through their methods of presentation of the material or the organisation of the work.

This is substantiated by Rowe (2003) who argues that quality of teaching and learning provision are the most important influences on students experiences and outcomes of schooling. Based on his review of national and international research, he concludes that what matters most is good quality teachers and teaching. Urdan and Schoenfelder (2006; 340) argue that the way teachers regulate the academic environment including material covered, approaches to learning and communication with students play an important role on student attitude to school. In their study on sources of early interest in science, Maltese and Tai (2009) find that the way teachers interact with their students rather than subject content knowledge, is an important factor in getting students interested in science. Thus, it is apparent from these and other researchers (e.g. Gorard and See 2009; Logan and Skamp 2012) that the way teachers teach in the classroom has an effect on the interest and attitudes of their students. A further study that extends these claims is Springate *et al's* (2008) suggestion that poor teaching tends to put off students from taking up science in the future.

Looking at teaching methods, Lyons (2006) suggests that transmissive pedagogy such as reading from a book or copying from the board leads to boredom and disengagement from science. He claims that the negative feelings arising from transmissive pedagogy affect student experience of school science leading to a skewed attitude to science. Similarly, in their interviews of Year 11 students (number unspecified), Gorard and See (2009;13) investigating the enjoyment of science in schools find that the most common complaint is that lesson delivery is unimaginative. They find that experiences undermining student enjoyment in science are passive events such as listening to a teacher, copying, note-taking and having to sit still for a prolonged period. In a more recent study, Hampden Thompson and Bennett (2011) conclude that greater levels of student enjoyment and future orientation towards science are found in classrooms where students report more varied teaching and learning activities. The key problem with this explanation is that although students enjoy different modes of learning, the ones that are effective may not be the type they enjoy. This point is highlighted by the Cerini *et al* study (2004) where students indicate that the three most enjoyable teaching and learning methods are (1) going on a science trip or excursion, (2) looking at videos, and (3) doing a science experiment in class; while they report that the three most useful and effective teaching and learning methods are (1) having a discussion/debate in class, (2) taking notes from the teacher, and (3) doing a science experiment in class. One interpretation of this is that caution is needed when trying to understand statements of enjoyment by students; on the one hand, interest is increased with 'fun' activities but achievement may be hindered if teaching is not effective.

From the studies above, it is seen that students enjoy science experiments as well as think they are effective learning methods. To illustrate, in their interviews of 80 A-level students, Springate *et al* (2008) find that the main thread throughout the interviews relates to practical work. They find that interviewees enjoy the practical aspect of physics and chemistry, and are encouraged to continue with the subjects when there is a significant practical element to their learning. Although this study is limited by its focus on students from ethnic minorities, other researchers using student samples reflecting a more comprehensive ethnic mix of students have also found similar results; students enjoy doing practical work and find it an effective way of learning (e.g. Osborne and Collins, 2000; Reiss, 2000). However, the concept of effectiveness is called to question by the Cerini *et al* study (2004), in which there is a mismatch of responses by students; when asked why they preferred increased practical content of the course, the most widely cited answer is that it makes it easier to understand theory. However, when the same students are asked whether new theory learned in class is explained by practical experiments, the most frequent response is 'just sometimes'. Such studies suggest that practicals may generate a situational interest only and are enjoyed by students because they create a respite from book work that they find boring. This viewpoint is supported by Abrahams (2009) who used a case-study approach for observing key stage 3 and 4 classes in different schools. He carried out individual interviews of teachers and students after the lesson to reach the conclusion that while practical work generates short-term engagement, it is relatively ineffective in generating motivation to study science post compulsion. He further concludes that practical work is also ineffective in generating a longer-term personal interest in the subject.

Thus, while students claim that they enjoy practicals in science and some research insists that a 'hands-on' approach will influence a positive perception of science (e.g. Abrahams 2009); few writers have been able to draw on any structured research on the influence of practicals on long-term interest in science leading to take-up post 16.

2.3 Individual influences

In this section, individual influences are defined as the characteristics and dispositions that students bring to learning such as interests, effort, values and perceived ability (Ainley 2004). There is acknowledgment that these dispositions do not act in isolation but have interrelationships with other factors such as attitude (Bennett and Hogarth 2009), gender (Brickhouse, Lowery and Schultz 2000), attainment (Wigfield and Eccles 2000), self-efficacy (Boe 2012), interest (Bybee and McCrae 2011) , aspirations (DeWitt *et al* 2011)and identity (Archer *et al* 2010). It is also acknowledged that these influences have a role to play in the perceptions and experience of school science as well as in the choice of science in the future; therefore, it is necessary to examine how existing literature reports these influences.

2.3.1. Age

A number of studies comment on student attitude towards science as students progress through their teenage years (Lord and Jones, 2006; Reid and Skryabina, 2002; Pell and Jarvis, 2001; Murphy & Beggs, 2005). For example, Springate *et al* (2008) find that students' enthusiasm towards the curriculum starts to wane during the primary phase and this carries on after transfer to year 7 with enjoyment and motivation across the curriculum tending to decrease throughout key stages 3 and 4. Similarly Bennett & Hogarth (2009) find that the number of students naming science as one of their favourite subjects declines between the ages of 11-14. Barmby *et al* (2008) find a similar steady decline in student perception of school science particularly emphasised in students at secondary school in Years 7-9. Lord and Jones (2006) also report that Year 8 students suffer the largest dip in motivation. This suggests that there is a growing negativity towards science in secondary school students. This steady decline in enthusiasm for science with age is consistent with the literature from the US (e.g. Simpson and Oliver 1990) suggesting that it is not just a national phenomenon.

Some studies suggest that the deterioration of interest in science starts earlier than secondary school. For example, Jarvis and Pell (2002) report a decreasing interest in science in their study of 978 primary school children. However, this is refuted by a large-scale, longitudinal study of 9,000 primary students by De Witt *et al* (2011) who find that overall students express positive attitudes to school science. However, both studies are limited by the student sample; Jarvis and Pell (2002) sample students from schools with intake from socially deprived areas while DeWitt *et al* (2011) include students from private schools in their sample.

Studies of interest in other subjects suggest that science is not a special case, but there is a wider alienation from the schools' curriculum offer. For example, there is an increased negativity evident for other subjects such as history (Harris and Hadyn, 2006). As Head (1997) reminds us, there is a general dissatisfaction with school as young people go through adolescence; a finding supported by Lord and Jones (2006) who claim that students' enthusiasm for school decreases as they get older. However, this is contradicted by Riley and Docking (2004) who find that 18% of Year 8 and 11% of Year 10 students indicate they are interested in at school; however, the focus of the study was on school work and not on school in general and this could account for the difference in findings.

Tai, Liu, Maltese and Fan (2006) analysing a large database of educational statistics in the USA, suggest that those students who show an interest in pursuing a science career before the age of 14 are 3.4 times more likely to earn a STEM degree compared to students who have expressed an interest in a non-science career. The Tai *et al* study adds to the growing evidence (e.g. Lindahl, 2007; Maltese and Tai, 2010; Barmby *et al* 2008; Bennett and Hogarth, 2009; Osborne, Simon and Tytler 2009) that school experiences between ages 11-14 are crucial in shaping students attitudes and subsequent behaviours in relation to subject choice. This suggests that school experiences at an early age have an effect on subsequent behaviours in relation to science. However, Foskett *et al* (2008) highlight that young people are still learning and negotiating new experiences and their decision making process is more likely to be volatile and subject to change; a view endorsed by Bennett and Hogarth (2009) who find that a student not liking science at an earlier stage may later choose to take science at post-16. This suggests that choice is not a clear-cut decision made at a single point in time but that it is a dynamic entity which exists at a particular moment and is subject to change. It is worth noting here that one of the aims of the current study is to examine the relationship between age of students and their decisions to take science or not.

2.3.2. Gender

Much of the existing literature on subject preference and subject choice focuses on gender differences with a number of studies in science education showing that female and male interests are different (e.g. Cerini *et al* 2003; Osborne & Collins, 2000, 2001; Scantlebury & Baker 2007; Schreiner, 2006; Bennett & Hogarth 2009; Barmby *et al* 2008; Jenkins & Nelson 2005, Quinn and Lyons 2010). These studies highlight that generally, females are more interested in issues to do with human health and well-being, whereas males are more interested in things to do with technology and physics. Thus, it is no surprise that Schreiner and Sjoberg (2007) find males outnumber females in physics and engineering studies while the gender balance is shifted in favour of girls in medicine, veterinary medicine, environmental studies and biology. Similarly, in the US, Aschbacher, Li and Roth (2010) find females continue to be under-represented in physical sciences, engineering and technology and Miller, Slawinski, Blessing & Schwartz (2006) find that females are more interested than males in the people-oriented aspects of their chosen science subjects, particularly biology.Similarly, in their analysis of PISA 2006 data, Buccheri, Gürber and Brühwiler (2011) find that gender is related to specific scientific interests and vocational choices along same patterns internationally.

In a review of articles about attitudes to science over the past two decades, Barmby *et al* (2008) find that boys are generally more positive about science than girls and with a less negative trend in their development of attitudes. Examining self-efficacy beliefs (see 2.3.4 below for definition) in both males and females, Bandura, Barbaranelli, Capara & Pastorelli (2001) find that female students judge themselves less efficacious for male-dominated occupations even though they are similar in verbal and quantitative ability on standardised tests. Taskinen, Asseburg and Walter (2008) find that females avoid vocational choices such as being engineers or technicians even if they have the same ability in science as their male counterparts. This perception of own ability is particularly damaging to girls as GCSE examination results for 16 year olds reveal that girls are as equally able as boys to achieve well in science (Gorard 2010). The combination of attitude and perception of their own abilities and qualifications are important factors when girls choose whether to take science or not. If they have a negative attitude to science as well as a flawed perception of their ability, they may decide that science is not for them. Not only does perception of own ability affect girls' choices to take up physics and chemistry but also the perceived difficulty of the subject. This is pointed out in *Taking a Leading Role* (Royal Society 2006a) where research shows that girls tend to be more easily influenced to drop physics and chemistry because of the perceived difficulty of these subjects. This is consistent with findings from studies from Australia (Quinn and Lyons 2011) and from the UK (Bennett and Hogarth 2009).

Although there have been many reasons put forward for the apparent lack of interest in and take-up of physics by girls, one of the reasons suggested by Aschbacher *et al* (2010) is how students see themselves in relation to the culturally biased science that is reproduced in schools; a finding that resonates with the Archer *et al* (2005) suggestion that the masculine image of STEM subjects may be incongruent to the perception of girls own identity. Adolescence has been identified as a crucial period in the development of a gender identity because individuals are transforming a 'childhood' gender identity into an adult one (Eccles *et al* 1983). They may, therefore, be particularly sensitive to gender stereotypes. Adolescent girls, faced with a conflict between the demands of stereotypical femininity, with its emphasis on social success, and the demands of high achievement may well feel that a way out of that conflict is to be successful only in those subject areas considered appropriate for females (Whitehead 1996). Thus, it is possible that some girls may not want to have an identity that is connected with being a physicist or an engineer (Schreiner & Sjoberg, 2007). This is supported by Quinn and Lyons (2011) finding that the most frequently endorsed reason for not choosing science is that females are not able to picture themselves as scientists.

2.3.3 Attainment

Gorard , See and Davies (2012) define attainment as an individual's level of success in educational assessments of any kind and this definition can also be applied to achievement. In this study, both terms will be used synonymously although it is acknowledged that achievement also takes into account students' starting points[13].

In a review of studies on student decision making, Wright (2005) concludes that academic attainment has an important influence on decision-making. This is supported by other studies that suggest perceptions and expectations of academic attainment are significant in the decision making process and appear to influence which subjects are taken at A-Level. For instance, physical sciences, mathematics and foreign languages are taken disproportionately by pupils with overall high levels of attainment (Bell, Malacova and Shannon 2003, Fitz-Gibbon and Vincent 1997). This is supported by Davies *et al* (2004) who find that pupils with higher measured levels of ability are more likely than pupils of other ability levels to be entered for science and maths and less likely to be entered for home economics. However, some studies suggest that pupils' subjective perceptions of their ability are a more important influence on subject preference and subject choice than their ability as measured by examination or test scores or observed by teachers. For example Colley, Comber and Hargreaves (1994) find that teacher ratings of students who tend to prefer more practical subjects (such as art and design, CDT and PE) compared to those who chose more academic ones (such as mathematics, science, and French) are similar –that is, students tending to choose more academic subjects are not more academically able. This, the authors suggest is because subject preferences are more to do with students' own perceptions of their ability. This relationship is further examined by Wigfield and Eccles (2000) who propose their expectancy-value theory (EVT) which helps explain student choice. The model predicts that students are most likely to choose courses in which they have high expectations of success. This is discussed further in section 2.3.4 below.

2.3.4 Self-efficacy

Bandura (1986) defines self-efficacy to be the confidence in an ability to succeed. Much research into motivation to learn (e.g. Zimmerman 2000, Eccles and Harold

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[13] For example, the achievement of a native French speaker attaining a high grade in GCSE French is comparatively less than the achievement of a similar grade in French by someone who is a non-speaker.

1991, Renninger 2009, Wigfield and Eccles 2000, Schunk 1991, 2000) reaches a consensus that self-efficacy is an effective predictor of students' motivation to learn. Schunk (2000) and other researchers (eg Wigfield & Eccles 2000, 2009, Schunk & Pajares 2002, Bandura 1986) have noted that self-efficacy influences choice of activity, persistence and effort and therefore will have some effect on attitudes to and decisions to take up particular subjects. This is supported by a review of the literature on interest generation by Renninger and Hidi (2011) who find that individuals who think they cannot pursue an occupation will not have an interest in pursuing it. This is important in terms of science choice since children with high self-efficacy are more likely to choose to continue with a task than children with lower self-efficacy (Bandura and Schunk, 1981). Similarly, Quinn and Lyons (2011) find that students are more likely to make science-related choices if they have high expectations of success in science. It is encouraging to know that self-efficacy is not a fixed and final quality as proposed by Renninger and Hidi (2011) who point out that if initial self-efficacy is low, it can develop later. Elsewhere, Boe *et al* (2011; 43) propose that expectation of success is influenced by perception of difficulty of the subject as well as the students' self-image in relation to this subject. This is supported by Bennett *et al* (2011) who find that students emphasising physics as being hard are less likely to take it up. Lindahl (2007) also concludes that attitude to science and self-efficacy both determine science choice.

2.3.5 Student identity

Closely related to gender, self-efficacy and 'self-concept' (Schunk and Pajares 2002) is the notion of identity. Identity is defined in psychological research as an individual's conception of their individuality (Lawler 2008; 1). Although there is a vast amount of literature concerning models of identity and identity formation (e.g. Marcia 1966, Kroger 2007), in this current study, a sociological approach to identity is taken because schools are social institutions and the development of a learner identity takes place through social interactions. Lave and Wenger (1991) emphasise the social element by arguing that learning takes place through social interaction within 'communities of practice' such as those found at home, work or school. They also argue that people gain a sense of self through social processes and shared experiences; thus, identities are what or who students wish to be in relation to these communities. This view is supported by a number of researchers who have tended to use a sociological approach to identity construction in acknowledgement that young people's values, views and ways of understanding themselves, their surroundings and the world in general are products of the culture in which they are growing up and that student identities are shaped by gender, race and class relations among other factors (Brickhouse *et al* 2000, Aschbacher *et al* 2010, Schreiner & Sjoberg 2007). For example, in their study describing the four girls' engagement with science, Brickhouse *et al* (2000) discuss that if students' engagement in school science is influenced by whether they view themselves as the kind of person who engages in science. The researchers conclude that there are three constructs of student identity; a decision about which group to identify with, what kind of person the student wishes to be within each group and what is required to become that kind of person. Also, Carlone & Johnson (2007) contend that a science identity is the sense of who students are, what they believe they are capable of and what they want to do and become in regards to science. These studies draw attention to the process of identity development as one that is both individual but also socially situated.

Within the issue of science choices and decision-making there has to be an assessment of one's abilities and interests to match these with a realistic sense of what different choices will involve. Most students when making a choice of subjects recognise that science is important as illustrated by Bennett & Hogarth (2009) who find that science outside of school is popular and while there is no decline in interest and respect for STEM subjects, there is a decline in willingness to opt for STEM related fields and careers.   Schreiner & Sjoberg (2007) suggest that the reluctance of young people to enter STEM careers has more to do with perceived values and images of STEM subjects rather than lack of respect or lack of knowledge. The values and images of science might be incongruent to the identity that the students wish to develop. Studies on science identities have shown a particularly fixed and lasting impression of STEM subjects and careers having a white, middle-class masculine identity (Whitehead 1996, Seymour & Hewitt 1997, Kessels *et al* 2006). Therefore, it is not surprising to find studies such as Hannover and Kessels (2004) that provide evidence of a mismatch between the student perceptions of what a scientist is and how they see themselves.

These and other studies highlight the critical importance of identity in students' choice to take up science leading to the result that while many students acknowledge that science is important, they feel it is 'not for them'.

2.3.6 Interest and enjoyment

Although it is acknowledged that interest cannot be equated with enjoyment of learning[14], since the students in the study use both terms synonymously this is the way they are presented in the literature review. This section is a review of the literature that links interest or enjoyment with school science experiences and science subject take-up; it is not intended to review the broader literature on interest from the psychological perspective.

In their inspection of 45 schools in England, OFSTED note in their *Guidance for Students Studying Science* (2010) that students choose science mainly because of their interest in and enjoyment of the subject. Other studies (e.g. Springate *et al* 2008, Bevins *et al* 2011, Krapp and Prenzel 2011, Boe *et al* 2011, Quinn and Lyons 2011) suggest that students who express enjoyment and interest with the topic content are likely to express a desire to continue their engagement with the topic. Ainley and Ainley (2011;5) in their assessment of 2006 PISA data, conclude that enjoyment of science is central to the prediction of students' participation in science activities. However, it can be argued that their findings might have been more useful if they had considered students participation in terms of subject choice instead of combining this with participation in science projects and career choice.

Krapp and Prenzel (2011) provide a useful account of the methods for assessing interests in science and conclude that interest level and the course of interest development in science subjects depends strongly on the perceived attractiveness of the curriculum's lesson content and on the manner in which scientific knowledge is presented and taught. Another point that bears an influence on the current study is Renninger's (2009; 106) claim that interest develops in relation to available experiences and to how learners perceive, understand and represent these experiences. The implication of this possibility is that interest development in science

[14] a point argued persuasively by Krapp and Prenzel (2011;30)

may be related to experience of school science. Some support for this comes from a study on early influences on science careers (Maltese and Tai 2009). They interviewed 116 science graduates and scientists about the early influences on their choice to take science. Analysing the data, they report that although the majority (45%) indicate self-interest (personal interest in science), a sizeable 40% of the respondents indicate that initial experience with school or an education-based activity such as science competitions were influential in their choice of science.

Another interesting point arising from this study is the analysis of the source of initial interest reported by male and female respondents. For females, the main source of initial interest was associated with school (52%) followed by self-interest and family influence (both at 24%). For males, the main source of initial interest is self-interest (57%) followed by school influence at 33% and family influence at 10%.

2.3.7 Attitude to science

The term attitude is generally understood to mean the feelings and thoughts an individual may have about a specific topic (Fishbein 1967; 77). The research literature on attitudes to science however, indicates that there are many definitions and interpretations of the term attitude. This is illustrated by the use of constructs such as interest (Barmby, Kind and Jones 2008), disposition to school science (Bennett and Hogarth 2009), scientific attitudes (Pike & Dunne 2010), science choice (George 2000), science subject choice (Stables 1990), perceptions of science (Korpershoek *et al* 2012), importance (Jenkins & Nelson 2005) and enjoyment (Breakwell and Beardsell 1992) in place of the term attitude. In this study, the use of the term attitude is limited to the thoughts and feelings that students may have towards science in school.

Ajzen (1985; 11) proposed the theory of planned behaviour (TPB) where actions are controlled by intentions and that in turn, intention to carry out certain actions relies on attitude to the behaviour, the social environment and an individual's belief of how easy or difficult performing the particular behaviour will be. TBP is a popular model for the prediction of science uptake in studies looking at the link between attitudes to science and science take-up (e.g. Sears 1997, Lindahl 2007, Osborne *et al* 2003).These studies reveal that having a positive attitude predisposes individuals to undertake a task in future. In contrast, other researchers (Bennett and Hogarth 2009, Lyons 2006)) point out that positive attitude to school science is not necessarily associated with science uptake. This is further supported by studies where students have a positive attitude to science outside school compared to that towards school science. For example Jenkins and Nelson (2005) using Relevance of Science Education project (ROSE) data, find that a large number of students indicate that science is a subject everyone should learn at school yet also indicate a personal dislike for science. This suggests that it is not just attitude to science that has an influence on preference or choice of science.

2.3.8 Motivation

Ryan and Deci (2009) propose that motivation is being moved to do something. They note the two different kinds of motivation; intrinsic motivation that refers to doing something because it is interesting or enjoyable and extrinsic motivation that refers to doing something because it leads to a desirable outcome. Reviewing three decades of research, they conclude that quality of experience and performance can be very different when an individual is behaving for intrinsic versus extrinsic reasons.

The literature on motivation in science points to a number of factors that influence motivation. For example Cerinsek *et al* (2012) contend that engaging and absorbing classroom experiences such as experiments can enhance motivation and foster an interest in the choice of studying science. Similarly, Maltese and Tai (2009) find that their respondents were motivated to take science because of school or education based experiences. On the other hand, Lyons (2006) found that motivation to take science was based on strategic value such as career value. However, this relationship exists only in terms of motivation to take physics; he finds that motivation to take biology or chemistry depended on school science experience and good teachers.

According to Eccles *et al* (1983) expectancy-value theory (EVT) suggests that students are more likely to take up subjects they see as useful and in which they think they will be successful. The EVT goes some way to give insight into the choice-making process in which people choose to pursue goals that they perceive as realistic, attainable and desirable. This view is supported by other motivation research literature (e.g. Bandura 1982) that refers to the importance of self-efficacy beliefs on student motivation.

These findings suggest that motivation to take science depends upon school experiences as well as individual factors such as self-efficacy and interest.

2.4 Wider social and cultural influences

Following Coleman's (1968) finding that schools and teachers had little effect on student attainment and that it was more to do with the home background, decades of research on school effects on student attainment has been published. Some findings were contradictory to Coleman's conclusions (e.g. Rutter *et al* 1979) while others supported his findings; such as the Plowden (1967) report that concluded lack of parental influence was the main reason some children fail at primary school. Similarly, Feinstein and Symons (1999) find that attainment depends more upon parental input and less on school input. They claim that the way parents influence their children's educational performance is about the amount of time devoted to children and the educational quality of that time. More recent literature (e.g. Maltese and Tai 2010; Sjaastad 2012) provides little doubt that students are influenced by their relationships and daily social interactions with important people around them such as family, teachers and peers. The influence of teachers has already been discussed above; this section starts with a discussion of the ways that families can influence educational outcomes generally in terms of socioeconomic status and social and cultural capital. It is followed by a discussion about the way families and peers influence decisions to take science.

2.4.1. The influence of families on educational outcomes

Some earlier studies in the field of educational choice have emphasised the role of broader social inequalities in shaping educational choices (e.g. Woods 1976). In more recent studies (e.g. Archer *et al* 2012), a Bourdieu-inspired approach is apparent in which researchers apply cultural and social capital concepts as well as the concept of habitus. Archer *et al* (2003b; 17) quoting Bordieu, defines cultural capital as the knowledge, language and culture that guides actions and decisions. It is a network of social relations or sphere of contacts that can help families access the best schools, universities and employment. This suggests that students' social capital is influenced not only by background characteristics (e.g., ability) and family factors (e.g., parents income and education), but also by the preferences and attitudes transmitted to children, and the way in which parents motivate their children, such as through encouragement of reading, critical thinking and attitudes to education.

This section starts with a review of socioeconomic status and social and cultural capital and their roles as predictors of school science experience as well as educational outcomes. This will be followed by a discussion on family and peer influence on subject choice.

2.4.1.1 Socioeconomic status (SES)

In general much has been written on the effects of socioeconomic status on subject choice (e.g., Royal Society 2008; Gorard and See 2009; Mensah and Kiernan 2010). One of the key problems of SES research is that while there is a large amount of research on the effects of SES on educational outcomes, there is little comparative agreement on the measure used for determining SES. Early British research relied on eligibility and / or take-up of free school meals (FSM) as an indicator of low SES whereas later research employs other methods to measure SES such as mother's occupation (Marks, 2007), number of books in the house (Wobmann 2003), residential postcode (Webber and Butler, 2007), income (Herrnstein & Murray, 1994) and size of family (Fischer *et al*,1996). Research from the US moved away from using single scales of SES to a combination of measures such as parental education, earnings, home ownership and occupation. SES research in the UK followed suit to introduce a multilevel measure of deprivation - the Income Deprivation Affecting Children Index (IDACI) - which looks at the percentage of households without a car, the percentage of lone parents, the percentage of adults with no qualification and unemployment rates.

Regardless of which SES measure has been used, most researchers are unanimous that future life chances are strongly influenced by SES (e.g. Ball, Maguire and Macrae 2000). For example Gorard and See (2009) conclude that students from a lower social and economic background that take science are far less likely to obtain high grades while students from more prestigious social class backgrounds tend to perform better in all subjects. These findings are corroborated by a number of other studies (e.g. Sammons, 1995; Marks 2007, Rothman 2003). Another effect of SES on educational attainment is highlighted by Coe and Tymms (2008) who find a marked gap in performance between students in maintained schools and their counterparts in the independent sector. They find that at A level, 31.1% of independent school students achieved three grade A's in 2007 compared to 9.9% of students in maintained schools. However, a limitation of this study is that the authors have not indicated what proportion of the independent schools included in the study is selective in their intake which may be the reason for some of the findings.

In their report from a study on aspirations of 16 year olds at school (Archer *et al* 2005) suggest that inequalities in economic resources have a huge impact on educational success. For example, lack of funds for compulsory expenditure such as uniforms, books and internet access can highlight this inequality on a daily basis; while poverty can also affect the learning environment at home with students unable to find adequate space and time for doing homework and coursework. Reay (2004) points out that less affluent parents may find difficulty in affording visits to libraries, museums and extra tuition. However, Croll (2008) finds that although children from more occupationally advantaged families[15] achieve better educationally, the career outcomes for students who are ambitious as well as educationally successful are just as good for those from disadvantaged backgrounds as advantaged families. This suggests that low SES factors do not necessarily constrain individuals but require the individual to have resilience to overcome the barriers.

2.4.1.2 Social and cultural capital

In the section above, the influence of SES on future life chances focuses on (lack of) economic capital; in this section the focus is on social and cultural capital. It is acknowledged that social and cultural capital cannot be divorced from SES, but some studies argue that SES is less significant than socio-cultural influences. For example, Mensah and Kiernan (2010) analyse the Millennium Cohort Study data for 7600 children whose mothers had been interviewed twice at five-year intervals, and for whom an educational assessment and family environment measure were available. They find that socio-cultural aspects of the family environment as reflected in the measures of mothers' education, age and the quality of the local area are more

[15] Those children whose parents are from families with parents who have professional, managerial or technical jobs.

significant than family economic resources. Foskett and Hemsley-Brown (2001) argue that the choices of young people are never free from the influence of their family and that the family environment is a product of its social situation. Other studies indicate that children's educational attainment tends to be poorer amongst families with very young parents (Feinstein, Robertson and Symons 1999; Hobcraft & Kiernan, 2001), lone parent families (Kiernan, Land and Lewis1998; Joshi *et al* 1999) and some minority ethnic groups (Sammons, West and Hind 1997; Strand 1999).

The contrasts between choice in middle class and working class contexts reflect differences in cultural capital of individuals and families. For example, Ball *et al* (2000) argue that middle-class parents seem to have clear aspirations and are pro-active leading to the greatest interventionary effect in choice-making at 16 and beyond while working-class parents cede decision-making to their child while either expressing concern at their choices or giving their backing. One explanation for this is that those parents who have no personal experience of higher education find it difficult to intervene effectively. For example, in their study on Bangladeshi girls' career aspirations, Smart and Rahman (2009; 13) conclude that few express interest in careers other than medicine because their parents know relatively little about jobs in other sciences, engineering or technology.

In their study of urban working class youth and their post-16 choices, Archer, Hollingsworth and Halsall (2007) also note that the unequal distribution of cultural and social capital provides the students with unequal chances of succeeding in education. They eloquently emphasise how middle class families tend to benefit from their superior knowledge and understanding of the education system which they use to maximise their child's educational choices. Similarly, Reay (1998) finds that while parents from both middle and lower SES backgrounds talked to the teacher and helped with their child's homework, only middle class parents are able to intervene in the shaping of the curriculum; a finding that resonates with West, Noden, Edge and David (1998) who find that well-educated mothers are more likely to supplement their child's school work, and to employ private tutors.

2.4.2. Family and peer influences on science subject choice

In the section above, the way that family contributes to the economic and cultural capital provided to a child in the educational stakes is discussed. The section below looks at ways that families have an effect on the science subject choice process.

Family background influences choice of subjects and take-up of science in a number of ways. The most obvious way is in terms of support, advice and encouragement. Analyses of international tests like TIMSS have suggested that home background is a determinant of achievement and subsequent participation in science across most countries. However, the research evidence on how far and in what ways the family influences subject choice is inconsistent. Families are often cited as significant forces in students' lives by serving as role models (Sjaastad 2012)and playing an important role in encouraging students' interest and decision to pursue science careers (Bennett & Hogarth 2009). For example, Gorard (2010) in his study of factors determining post-compulsory participation notes that students from professional family backgrounds are more likely to stay on in education after 16 and want a professional occupation themselves. Cleaves (2005) study finds there is a significant influence of parents on subject choice of more able students. However this is contrast to Foskett and Hemsley-Brown's (2001) findings that parental influence over young people's decisions decreases over time. They find that parents appear to exert influence over some decisions more than others. For example, parents have a strong influence over the choice of whether to participate in post-16 education but other decisions such as choice of subjects, qualifications and institutions is left to the student. Lindahl (2007) concurs with this, finding that only one of the eighty students she has interviewed has 'had to' take science because of parental wishes. Springate *et al* (2008) also find that parental influence is not as strong an influence as interest on student choice to take science.

There is some evidence that parental influence differs by ethnicity (e.g., DeWitt *et al* 2012). For example in their study of subject choices in ethnic minorities, Springate *et al* (2008) find that the influence of families is stronger for Bangladeshi and Pakistani students and weaker for Chinese students. Pakistani and Indian students are more likely than other groups to be steered away from physics and chemistry careers through the influence of their families who are in other professions, such as medicine, pharmacy and law. Cultural influence can also manifest itself through parental influence. For example, a majority of Springate *et al's* (2008) Indian, Pakistani and Chinese students felt that they were directly influenced by their parents' culture to do well and continue in education.

Cleaves (2005) finds that students are discouraged from taking science due to parental perceptions of the subject. This resonates with Springate *et al* (2008) finding that while most parents encourage their children to take sciences at A-levels, they discourage them from doing pure sciences at university as they do not feel there are any direct career opportunities available with a chemistry or physics degree. This is supported by Lyon's (2004) report of his PhD study in which he surveyed 196 students and interviewed 37 15-16 year olds. He finds that with the exception of one case, all of the interviewees choosing physical science subjects described supportive relationships with a parent or family member whose attitudes to education, or science, favoured such a choice. Also, in his study of significant persons influencing a STEM career choice in 5007 students, Sjaastad (2012) finds that 22% of the students attribute parents as the source of inspiration to follow a STEM career compared with 9% attributing their teachers. It appears however that he did not analyse responses where students do not mention a significant person influencing their decision.

2.4.3. Peer influence

Some research has indicated peer attitude and interest in science to be a predictor of student enjoyment of science (e.g. Aschbacher *et al* 2010, George 2000) and sharing science interests with peers enhances students' vision of themselves as future scientists (Stake & Nikens, 2005). Reiss (2000) and DeWitt *et al* (2011) both note that peers affect how science is experienced at school. However, despite the suggestion that peers influence attitudes to science, a number of studies studies suggest that few young people choose a particular post-16 route merely because their friends have chosen it. For example, in a study commissioned by NFER looking at post 14 and post 16 choices, Blenkinsop, McCrone, Wade and Morris (2006) carried out interviews of 165 students where they were asked to complete a 'circle of influence' activity which sought to explore the level of importance and value that young people gave to the various influences on their decisions they had identified. The researchers find that very few of the students located their friends in the centre of their circle of influence. They also find that over half of the students indicated that while they talked about their choices with friends, they did not pick subjects that their friends were doing. This suggests that while peers may have some influence on attitudes to science, there is little or no evidence that they influence science career choice.

2.5 Instrumental influences on subject choice

Instrumental influences on subject choice are those influences that lead students to choose to take science because of their career goals, for gaining admission to science or non-science university courses or for some other extrinsic reward such as praise or accolade from significant others (parents, family, teachers, peers). It is acknowledged that these influences do not act in isolation and may be affected by many of the other influences above such as self-efficacy, identity and interest.

OFSTED in their *Guidance for Students Studying Science* (2010) note that students choose science partly because of their particular career intentions; this is supported by Cleaves' (2005) study of student choice of science where she finds that science is chosen as a post-16 subject mostly by students who need it for a specific career ambition. Similarly, in a review of research literature, Tripney *et al* (2010) conclude that the usefulness of science as a career is the most influential reason for taking science. This suggests that career value has an instrumental influence on subject choice. This section reviews the career choices as an influence on subsequent choice of science.

In their study spanning six countries Woolnough *et al* (1997) look at the factors that affect student choice of career in science and engineering. They find that there are a number of inter-related factors that influence science career choice and that many of these are common across the range of countries. They find that a scientific background, a student's ability and personality are important indicators of whether they will continue with science or not. In addition, the status, salary and job satisfaction that society accords to careers in science are also influential. They note that the in-school factors that influence science career decisions are the quality of science teaching, the science content taught and the way teachers encourage students as well as involvement in extra-curricular activities related to science. The finding that school experience of science plays an influential role in choosing science as a career is corroborated by other studies. Schoon, Ross and Martin (2007) drawing on data from the British Cohort Study find that interest and attachment to a science career are formed early in life and that school experiences are crucial in attracting young people to a career in science.

Another way that schools play a role in career choice is by the information, advice and guidance that they provide to students to help them make informed decisions about their career pathways. In the DfE (2010) report described above, it is seen that when making KS4 choices in Year 9, most students sought advice from family and friends with fewer talking to careers advisors or teachers at school. In a review of careers advice in schools, Morris (2006) finds that careers guidance practices and quality were highly variable. The implications of this are reported by Blenkinsop *et al* (2006) who conclude that in schools where effective careers education and guidance was in place, young people seemed to be thinking through their choices more rationally and weighing up all the information they received. In their report commissioned by the DFE *Subject and course choices at ages 14 and 16 amongst young people in England* (2010), the authors describe 'framing effects' operated by schools that influence young people towards certain options both in terms of subject choice and subsequent career pathway. They exemplify this with schools' use of courses and combinations that would bias choices towards defaults. They briefly mention how the way schools' presentations of subject and course choices could affect choices that students eventually make. However, the limitation of their study was the lack of information about the way that different schools presented course and subject choices to the students. This information would help give an insight into how students could be forced to make particular choices.

One question to be asked is how timing of decisions and choices affects career aspirations. A body of evidence indicates that many students decide whether they want to take science as a career quite early on in school (Maltese and Tai 2009, Cleaves 2005, Archer *et al* 2005). The Royal Society report *Taking a Leading Role*

(2006a) finds that young people first begin thinking about working in STEM careers at a variety of ages with just over a quarter of respondents (28%) doing so before the age of 11, a third (35%) between the ages of 12 -14 and a third (31%) between the ages of 15-18. Foskett and Helmsley-Brown (2001) argue that choosing an academic route tends to start earlier than choosing vocational pathways; this is supported by evidence from studies (e.g. Cleaves 2005, Archer *et al* 2005) that indicate some young people adopt a 'wait and see' attitude, deferring making decisions about their future until after their GCSE results. This has implications for the timing of careers advice.

2.6 Conclusion

In this chapter, the literature on factors that influence experience of school science and the factors that influence choice to take science are reviewed. There has been an attempt to unpick the complex nature of interaction of influences on students' experiences of school as well as student choices.

In general, the literature review indicates that science choices are impacted on by a broad range of influences such as social and cultural background, identity, self-efficacy and so on that are equally important as school experiences of science. There is also some indication that these influences not only affect science choices but also school experiences.

The literature review indicates two main gaps in the research field. Firstly there are very few studies researching school science experience in decisions to take up science in the future and secondly there is a dearth of studies about school experiences of science in the English context. A composite image of student's experiences of school science developed during the secondary school years may have significant implications for understanding why students choose to pursue the study of science or not beyond the compulsory years. This is the rationale underpinning the current study.

The next chapter details how the literature review informed the research questions and provided a framework for examining students' experience of school science and the factors that influenced them to take science.

Chapter 3: Research questions

3.1 Introduction

This chapter is a discussion of the how the literature review of the previous chapter helped shape the aim and the related research questions of this study.

A large number of the studies reviewed in that chapter used large sets of national data and international data such as the National Pupil Database (NPD), TIMSS, PISA and the Millennium Cohort Study (e.g. Schreiner and Sjoberg 2007, Coe 2008) but surprisingly few studies have explored students' reflections of their school science experiences through interviews; evidenced by the fewer number of studies that interviewed students and presented their perspectives (e.g. Cleaves 2005, Lyons 2006). In order to establish how school experiences shape future choice of science, this study is set to explore student perceptions of school science and their subsequent take-up of science. It is intended that this study contributes to the research field by presenting the perspectives of young people in secondary schools in the era of post-2006 science curriculum changes. The findings will be used challenge, support or further clarify the influences reviewed in the previous chapter as far as possible within the narrow scope of school-based influences explored in this study.

In addition to the gaps identified in the literature (see Chapter 2 conclusion) that have helped generate the research questions, there are some gaps in methods too. For example, some of the studies reviewed focus on data collection from students who have chosen to take science (e.g. Maltese and Tai 2009). The current study included students who chose not to take science as well as those who have chosen to take up science post-16. Additionally, most studies relied on either interview or survey methods. This study attempted to gain deeper insight into school science experiences influencing students' post-16 decisions by using both survey and interview approaches (discussed further in the next chapter). It is intended that the interaction between both methods would help uncover detail that is not evident in previously published studies and reports.

It is important to clarify here that when the literature search and reading on the subject was started, it was evident that there was a dearth of literature focussing on school science experience as an influence on choice to take science. There was little literature dealing with a relationship between school science experience and take-up of science post-16. Reports and reviews by the Royal Society and government bodies either discussed choice of subjects in general or dealt with STEM subjects as a whole. Many of these studies looked at choices of science students, ignoring the voice of those who had opted not to take science. However, towards the end of the research period, a number of articles about the effects of school experiences and choice of science were published where the authors had interviewed students and presented their perspectives (e.g. Lyons and Quinn 2010, Bennett *et al* 2011). The latter study identifies a typology of strategies for choosing to take science which form a useful conceptual framework for understanding how students form choices; taking into account the complex factors that influence subject choice discussed in the literature review as well as the more individual personal factors such as interest and attainment. However, this study was published after the research data for the current study was collected and therefore could not benefit from the insight provided.

Based on the literature review in the previous chapter, the main aim of the study is to find out what role school science experience plays in the choice to take science post-16. The three research questions arising from this aim were introduced in chapter 1 and are now set out and justified in the sections below:

3.2 Research Question 1

The literature review in the previous chapter indicates that school experiences are crucial in attracting young people to a career in science and that one way of encouraging more students to take up science post-16 is to make school experience more relevant and engaging for young people.

The literature review highlights that perceptions of school science influence the decision to take science later (Cleaves 2005, Lindahl 2007Maltese and Tai 2009,). Despite the different emphases found in the conclusions of these studies reflecting different methodological approaches, different population samples and different educational settings; the studies above reveal a distinct pattern showing that experience of school science has a large influence on students' choice to take science in the future.

Personal experience suggests students are enthusiastic about science in Year 7 but gradually become disengaged by the time they reached year 9. This study enables the examination of students' points of view about the phenomenon. Historically there has always been interest in student thought and action as they engage in learning and other classroom activities. Although the study of schooling from the students' perspective dates back to the late 1960's (Weinstein 1983) and the interest in studying student views about classroom phenomena has led to large number of studies; these have typically involved aspects of school life such as teachers, peers, the classroom and the school. The study of student perceptions of subjects is a relatively recent addition to the field with studies of student perceptions of science gradually increasing in number.

One of the aims of the study was to understand the experience of school science that students may have and led to the first research question:

What are students' perceptions about their school science experiences?

In terms of this study, RQ1 aims to provide a view of school experience of science from the perspective of students who have chosen to take science post-16 as well as those who haven't chosen science. The intention is to present the voice of the participating students about their past experiences in science as well. This will provide insight into which school influences students feel have made a positive or negative impact or indeed, if they feel indifferent to the whole school science experience.

3.3 Research Question 2

A substantial amount of recent research on subject choice is available (e.g. Cleaves 2005, Lindahl 2007, Foskett *et al* 2008, Gorard 2010,) that indicate many reasons why students decide to take science or not. These have been reviewed and grouped as school, individual, social and instrumental influences in the literature review. However, it is intended to find out the views of the particular cohort being studied; therefore, the second research question is

What are the reasons students give for deciding to study or not to study science post-16?

Although the findings may overlap other studies, for the sake of completeness, it is necessary to compare the findings from the current situation in English schools with the findings from other earlier studies. This will help highlight similarities and differences between different cohorts of students from within the English context as well as the international context.

3.4 Research Question 3

In his PhD study, Lyons (2006) finds that almost half of the high-achieving students choose not to enrol in science courses despite a personal interest in science. Krapp and Prenzel (2011; 35) offer a plausible explanation for this inconsistency by noting that science interest is dependent on quality and type of instruction; a finding corroborated by Cleaves (2005) who reports that some students experiencing disappointment with school science do not continue.

Although there is literature from the psychology field about the possible link between experience of and attitude towards an action (e.g. Eccles *et al* 1983, Renninger 2009), this link has not been examined in the context of school science choice. For example, there is no shortage of studies on attitude to school science (e.g. Osborne *et al* 2003) and despite the many different interpretations of what attitude may be there is an agreement that students find school science to be irrelevant, complex, content-laden; forbidding further investigation or questioning. With such conclusions, it is not difficult to assume why students are put off taking science further. A further question emerging is why do some students who take science further seem to be resilient to these negative influences and persist in taking science further?

Of the school variables that may influence the process of subject choice, the literature review discusses studies looking at the role of school leadership, management and ethos but the paucity of research in student experience of school science[16] is the reason that this specific perspective is sought. In this study, the role of schools from

[16] Two main studies that study school experience of science and its influence on science enrolment decisions are Lindahl (2007) and Lyons (2006); however neither study is set in the English context.

the student perspective will be examined with an aim to understand its influence on choice to take science. The third research question addresses these issues.

> *What role does school science experience play in student decisions to study or not study science?*

From RQ1 findings of students' experiences of school science and RQ2 findings of the key influences on choice to take science or not, the insight from these two questions will help examine the role school experience of science has on decisions to take science.

Chapter 4 Methodology

4.1 Introduction

The previous chapter details the research questions for this study while this chapter describes the methodology of the current research study including a description of the research design and of the research methods. The design of the study and implementation is described as well as a justification of the methods chosen. This is followed by an account of the sample population and the pilot study. Finally the chapter ends with a discussion of ethical implications and data analysis methods.

4.2 Methodology

In this study, I began with research questions arising from the literature review and then chose methods for answering them. From the literature review I identified my research aim to be examining the role that school science experience plays in the decision to take science or not post-16. Three interrelated, but distinct, research questions have been discussed in the previous chapter. To answer these questions, I looked through similar investigations to review the methodology and research design before deciding how to approach my own study.

My interpretation of the meaning of methodology from the literature (e.g. Bogdan and Biklen 1992; Bryman 2008; Silverman 2010; Punch 2009) is that it refers to a set of methods about the way research in a study should be carried out. For this study, a comparison of advantages and disadvantages of qualitative and quantitative methods was made as outlined in table 4.1 (see below).

Table 4.1 Comparison of advantages and disadvantages of qualitative and quantitative research methods[1]

Advantages	Disadvantages
Qualitative research design: Detail / depth No restrictions on questions (in terms of how many) Research frameworks can be revised Interested in human experience	***Qualitative research design:*** Dependent on skills of researcher Rigour of questions hard to maintain Analysis/interpretation time consuming Researchers presence may cause bias Not generalisable Subjective
Quantitative research design: Large amount of data leading to statistical significance Eliminates subjective bias Useful for testing hypotheses Generalisable Objective Uncovers general patterns and relationships	***Quantitative research design:*** Too superficial Hypothesis needed before study – issues need to be known Evaluative not generative data Can be structurally biased

[1] adapted from Bryman, 2008, Punch 2010, Grix, 2004 and Silverman 2010

Noting the advantages and disadvantages of both types of research design, it was concluded that in a quantitative research approach, the large amounts of data although allowing generalisability would results in a superficial treatment of student perceptions. Qualitative data would lend a richness and description that would enhance the quantitative findings; on their own, the qualitative results may lead to a subjective interpretation depending upon a smaller sample and therefore be less representative. Thus, I concluded that a mixed methods approach was needed (as explained in 4.2.1).

4.2.1 Mixed methods

A useful interpretation of Tashakkori and Creswell's (2007;4) definition of mixed methods research is that data is collected and analysed using both qualitative and quantitative methods and approaches in a single study. Using this approach, I can collect both qualitative and quantitative data to help answer the research questions in a mixed methods approach. As Cresswell (2002) points out, mixing both qualitative and quantitative data will help to understand the research problem more completely. Although it is possible to collect both qualitative and quantitative data using a single instrument, I wanted to use two different instruments for collection of multiple sources of data; allowing the reduction of error and an increase in validity of the data.

4.3 Research design

A number of authors that focus on research design (e.g. Bryman 2008) point out that the methods used to collect data have to be considered carefully as they determine the shape of the research study. Before I made a choice of methods, I looked at the research designs of other similar studies to see what instruments were used in each and the advantages and disadvantages of each (see table below).

Table 4.2: Research designs used in similar investigations and a justification of why/why not they are suitable for the current study

Research design	Study	Justification for using this method	Justification for not using this method
Quantitative	Woolnough 1994	Background theory informs study Survey questionnaire easy to administer May highlight differences between subgroups Hypothesis led	May not go beyond attitude Need a large sample
Qualitative	Cleaves 2005	Small number of interviews to gather empirical data Grounded theory approach of interviews means it is independent of other research findings	The data collected is only as good as the researcher's questions
Longitudinal	Lindahl 2007	Allows tracking of changes over time Provides wealth of data for comparisons between subgroups as well as individually	Time consuming – over years rather than months Greater chance of sample attrition Data intensive Costly process
Ethnographic	Reiss 2005	Small sample Detailed	Issues of access Difficult to generalise Subjective
Case studies	Bennett et al 2011	Suited to 'how' and 'why' questions Focus on contemporary events (as opposed to historical events) Limited sampling frames - Single / multi cases Exploratory study	Labour intensive Data intensive Attrition may be fatal to study

I wanted to make a comparison of science and non-science students as I thought it would be possible to isolate traits of behaviour associated with each particular group of students. Apart from this, I was limited by time and resources; so based on this, I concluded that the two instruments suitable for answering my research questions are survey questionnaires and interviews. The literature review indicated that survey questionnaires are used in most research related to the uptake of subjects and it was decided that since the background theory needed to inform the study were already known[17], a quantitative approach would be the best method to collect a large amount of data that would be a more representative (although still limited) sample to help highlight differences between students.

From the research literature it is apparent that semi-structered interviews are a tool chosen in related research examining individual perspectives. Semi-structured interviews would have the flexibility to build upon individual student responses and examine what the situation looks like from a student's perspective. Thus it was decided to us both quantitative (survey questionnaire) and qualitative (interviews) methods to collect data.

4.3.1 Setting up a two-phased study

Cresswell (2002: 4) describes a two-phased study as one in which data is collected at separate stages using different methods. This is the form that the current study took; a survey questionnaire was devised to elicit both qualitative and quantitative data about school experiences and choice to take science or not. Then a sample of students completing the surveys was interviewed in more detail about their experiences of school science and the factors affecting their decision to take science or not. The phase model allowed me to investigate and analyse a range of aspects of school science experience and the process of science choice, affording a chance to refine interview questions in the light of emerging findings.

4.3.1.1 Phase 1: The survey method

In this section I will discuss the survey method used in the current study which consists of the storyline instrument (described below) and additional survey items. First there is a general discussion of justification and limitations of the survey method followed by the details of the survey questionnaire used to collect research data.

[17] From the literature review the kinds of school factors that have an effect on student decisions to take science – examination results, teachers, curriculum content, options allowed by school, careers.

Justification of the survey method

The survey method is an effective data-collecting technique as it can be carried out in a relatively short amount of time and allows responses to be collected from a large population sample. The large amounts of data allow for statistical tests of significance to be made. Although there may be some subjectivity in choice of questions[18], there is less chance of observer subjectivity[19] particularly where the survey is administered by a third party. The survey method involves a reasonable cost in terms of time and administration as compared to a labour intensive method such as interviewing. The survey method can be carried out in realistic settings – in the case of this study, the survey questionnaires were administered to students in their classrooms at school. This helps increase the validity of the survey instrument since the students answer the questionnaires in natural surroundings with teachers with whom they are familiar. However, this may introduce further problems in that teachers may be rushed for time and do not allow students time to complete the survey in a considered way.

Limitations of the survey method

Survey questionnaires tend to be seen by students as boring and they do not like lots of writing (Oppenheim 1992). I addressed this issue to some extent by making sure the items were short and where possible, included items where students may simply tick or circle around choices. I decided to ask students about details during interviews instead of getting them to write out responses to a great number of questions. Another problem with survey questionnaires is that inappropriate wording or placing of questions can cause a bias – I addressed this issue by making sure that the face validity[20] of the survey items was checked. Inflexibility is also a problem with survey questionnaires in that the items are inflexible because they cannot easily be changed to suit particular circumstances since this would reduce comparability between the different versions used. In the case where large numbers of questionnaires have been printed, any mistakes on the printed questionnaires are costly and time consuming to

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[18] E.g., the researcher may limit the range of answers the respondent can give by setting a limited number of answers to select.

[19] By influencing students to answer in a particular way through introduction of the context of the study

[20] This was established by asking people who had experience in the field to act as judges to determine whether the survey items reflected the concept I was measuring (Bryman 2008:152)

rectify. A further limitation is that the same questions have to be answered by all respondents and do not have the potential to reach beyond population trends. The pre-specified selection of choices may also limit the choice process of the respondents. These limitations are inherent in survey questionnaires and careful wording of the questions was used to overcome these problems.

The survey questionnaire

The survey questionnaire was designed to collect both qualitative and quantitative data in the form of what is called a 'storyline' graph (see below for an example of the graph) along with other survey items. Both these parts are designed to elicit students' experience of school science over the previous six years of schooling and to investigate which school factors had an influence on choice to take science or not (see appendix B). Further details of the storyline instrument follow below along with justification and limitations of using this instrument.

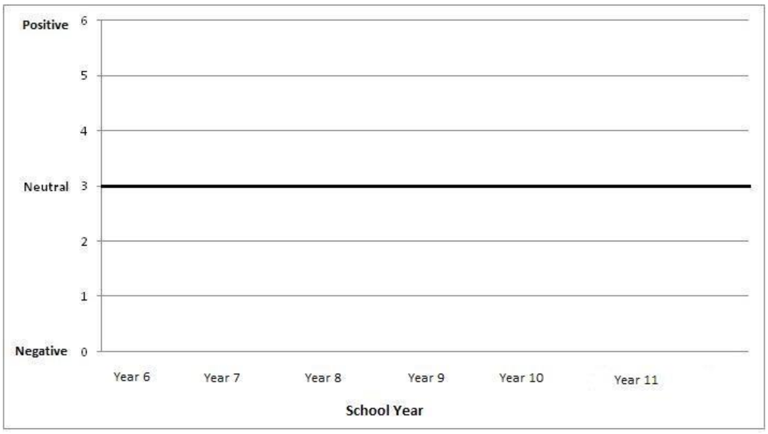
The storyline instrument

The current study used a modified version of the storyline instrument in a quasi-longitudinal approach[21]. The storyline instrument consists of a graph or chart with a scale of 0-6 on the vertical axis and school years from Year 6 – Year 11 on the horizontal axis (see fig 4. 1). The student indicated their overall judgement of school science in each year by drawing a point corresponding to the numbers on the scale. A point at 0 would indicate a very negative experience and a point at 6 would indicate a very positive experience. A point at 3 means the student had neither positive nor negative experience of science. Bryman (2008; 243) suggests that when asking respondents to choose between multiple points on a scale one must make sure that the choices provided are balanced. I made sure that the scale on the storyline graph had a balance of points above and below the neutral '3' so that the students' answers were not loaded in favour of either negative or positive perceptions. I chose the scale to start from Year 6 so that there is a baseline for the student's points during secondary school (Years 7-11). This would help distinguish which students had a very negative or positive experience of school science from primary school.

[21] This study does not follow a traditional longitudinal method where students are surveyed or interviewed at multiple stages over a course of time; it is a retrospective view of their experiences over time but collected at a single point; hence quasi-longitudinal.

Once they completed the storyline graph, students are instructed to explain the reasons for high points and low points in their graph. Both the storyline graph and the answers to this question provide evidence for RQ1 about student experience of school science. My main assumption was that the trajectory of the storyline graph is a sum of the students' experience of school science. This has limitations which are discussed below.

Figure 4.1 Storyline Instrument



Justification for using the storyline method

The storyline method was first used by Gergen (1986) to look at college students' general feeling of well-being. It was later used by other researchers to look at teacher's prior experiences (Beijaard, 1995), teacher's pedagogical content knowledge (Beijaard, van Driel & Verloop, 1999; Dreschler & van Driel, 2008), reflection in teacher education (Conway, 2001), science teacher's learning (Henze, van Driel and Verloop 2009) and as an alternative to interviews in healthcare (Thomas *et al*, 2009). These studies highlight the use of the storyline method as a narrative tool. In recent decades, narrative as a research methodology has become a popular method of inquiry (e.g. Connelly & Clandinin 1990; Elliot 2005).The narrative experience is described by Punch (2009; p38) as an account of an event or several related events described by a person who was involved in the episode as an active participant. In other words, narratives are stories about influential incidents in a person's own life. The main advantage of using a narrative approach is that it has the potential to demonstrate both the uniqueness of individuals' lives and the similarity between individuals under different circumstances (Thomas 2003). In their review of the storyline method Beijaard *et al* (1999) conclude that it is helpful in evaluating changes through individual teachers' careers. Similarly in my use of the storyline method, I thought it would be helpful in encouraging reflection on events during their school years. An advantage is that the respondents reflect on their experiences throughout their six years at school and interpret them; which is a difficult task for a researcher trying to interpret their narratives using other research methods. For example, researcher and respondents have different frames of reference and it is likely that the researcher interprets the respondent's story in a different way than intended by the respondent. This reflective process gives students a chance to present their own 'story' and allow their voice to be heard.

The storyline method employed in this study is altered to the way it was employed by other researchers mentioned above. In their studies, the researchers use the storyline graph as a tool to be completed in the presence of both researcher and respondent in an interview situation. The researcher explores each point with the respondent as they are drawing their storyline graph. Although there are certain advantages to this way of carrying out the method, such as being able to question there and then what is fresh in the mind of the respondent instead of coming back later after weeks or even months to ask the details drawn in the graph; however, I decided that I wanted to use the storyline method in a different way from the original method. The main reason for this was that I wanted respondents to answer other survey items at the same time and the interview time-frame was not long enough for all this to occur in one session. So it was decided that students complete the storyline graph as part of the survey questionnaire and that I would ask questions about the storyline later in an interview. Two other considerations also played a part; firstly, I had an idea that there would be a number of different types of graphs and that carrying out the storyline method in the manner Gergen suggested would limit the number of graphs I would obtain. Secondly, students may feel pressurised to complete the graphs in a short time in the presence of the researcher, thereby possibly affecting the way they completed the storylines.

One of the main advantages of using the storyline method is that it provides an opportunity to gather potentially rich and descriptive data, while also giving respondents an interesting way to record their experiences. Conway (2001) points out that the storyline method is often perceived by the respondents as an interesting and creative mode of self-expression (p94). In the literature review there are many studies which investigate student attitudes and perceptions to science and that tend to standardise students' responses to pre-defined categories (e.g. Kind, Jones and Barmby 2007), with little opportunity to establish the meanings or contexts behind their responses (Lyons 2006). The use of the storyline method helped to address this issue by enabling students to interpret their reasons for high and low points in the graph and gave them a chance to explain the meanings and context behind their high and low perceptions.

Limitations and delimitations of using the storyline method

The main criticism of the method lays in its retrospective viewpoint in which students are required to reconstruct past events. These types of studies are subject to the weaknesses of accuracy, recall and post-hoc rationalisation (White 2007: 51). This is also highlighted by Gergen (1988; 28) who points out that memories constructed from the viewpoint of the present may not be 'like a photograph, fixed and final'. It is acknowledged that as more knowledge is gained and new perspectives develop, students may forget details or remember different details; interpretations and hence stories may change. Sikes and Gale (2006) warn that this is something that all users of narrative approaches should acknowledge about the nature of their methods. Thus, changing stories is a problem with any type of narrative approach and not exclusive to the storyline method. The mixed methods approach of the research design is an attempt to triangulate the students' stories and help increase the credibility of the stories.

Gergen (1988) points out that another disadvantage of the storyline method is that the information collected can sometimes be too general and fail to do justice to relevant details. In the case of the current study this is further compounded by the necessity to reduce the size of the graph to fit on an A4 size sheet of paper[22]. For this, the students had to depict whole school years in a single point. So it could be questioned that when students put down a point for Year 7, for example, did they intend to convey their feelings about the beginning of year 7 or the end of Year 7? It is acknowledged that

[22] To keep to the idea that the survey questionnaire should fit on a single sheet of paper and not put students off if they had to complete many sheets stapled together.

this is a design limitation of the graph when used in this way; adding points to each year will make the axis of the graph too crowded and confusing especially if I asked students to mark points for the beginning, middle and end of each school year. I also had an idea that students may not remember particulars of each year in such fine detail. It is assumed that the single point they drew for each year was enough to trigger a student's memory of a critical point in that year. In the interviews, the students were able to explain the 'story' behind their single point for that school year. I asked about finer details of each year during the interview which some students were able to supply while others just talked about their experiences of a particular year in general. To make sure that the information collected with the storyline graph is not too general or fails to do justice to the detail of a respondent's story; I asked students to describe events that influenced high and low points in the graph in order to unpack their stories. It was also found that with less detail recorded on the graph itself, it was much easier to understand the trends and changes in trend rather than if there had been many data points per year. In conclusion, I felt that although I may have gained a more detailed perspective of each individual student if I had followed Gergen's technique of applying the storyline method; I would have gained far fewer varieties of storyline graphs and would have been unable to decide if I had achieved the full range or not[23].

The survey items

Besides the storyline graph and its associated questions, the survey questionnaire elicits information from the students about their choice of subjects at A-level and their choice to take science or not at university. It also contains open and closed items to elicit further details about the students' experiences of school science as well as their reasons for choice of science or not (see Appendix D for a copy of the final survey questionnaire). The original questionnaire (Appendix C) was developed over a number of months to take into account ideas from the literature review. Below is a discussion of justification and limitations of the survey items that form part of the survey questionnaire.

[23] For example, if all the graphs obtained were of only one or two types of trajectory.

Justification and limitations of the survey items

The storyline graph was used as the first section of the survey instrument and is described above. In addition to the storyline graph there were a number of items on the survey that consisted of different formats; dichotomous answers, closed and open-ended questions as well as multiple choice items asking for either one option or all that apply (see appendix D). These items were chosen with a specific design; to make the answering of the survey instrument as short and easy as possible. Oppenheim (1992) notes that students are often slow writers. Coupled with factors such as a short time to complete the questionnaire as well as the tendency to become bored easily, the reliability of answers to open questions becomes problematic. In this case, closed questions are the simplest and quickest ones to answer. However, to keep the narrative rich and to allow respondents to provide context and meaning to their answers, I provided room on the questionnaire for students to respond in more detail if they wished.

In the first section of the survey questionnaire, there are a number of demographic questions that will provide information regarding students' a) name and gender, b) subjects they are taking at post-16 to help give an indication of whether they are scientists or non-scientists (a full discussion of this characterisation is given in Section 4.9 below) and c) whether they plan to take science at university[24] – this helps categorise whether the student will take science in future or not. The need for students to write their names at the top of the survey instrument clearly raises important issues of research limitations and ethics.

The ethical issues for the whole study will be discussed below, but the design limitation for this is that respondents may be less frank and open when they know that their responses are not anonymised. I sought to overcome this limitation by asking that the survey questionnaires are completed and returned in such a way that no-one else apart from the researcher sees student responses and that students were assured

[24] This involves students' own judgement of whether they are taking a science subject at university.

by their teachers that this was the case[25]. I could have used a number system in which I designate each survey questionnaire a number and ask students to write their names against the number on the survey questionnaire on a separate sheet. However, this would have introduced administrative delays and I decided to keep to the original method of writing names on the sheet to aid compliance of teachers.

Question one is the storyline graph and its two associated open questions explaining their high and low points. The findings help answer RQ1 about the experience of school science.

Question two is focused on the time the student decided to take science or not at post-16. Data collected from this indicates the stage / age at which the decision to take science in the future or not was taken. It also provides evidence for the research question about patterns in timing of decisions as well ancillary support for RQ2 about the key influences on decision to take science. The limitation of this question is that the students completing the survey are all in Year 12. The main reason for their choice to take science or not may be strongly linked to their success or otherwise at GCSE. This issue will be addressed through individual student interviews where the timing of science choice will be probed in more detail.

Question three is a dichotomous item about whether the student feels that school science has had an influence on their choice to take science or not in the future. If they answered in the negative, there is an open ended section where they can explain what influenced their decision to take science or not. The data collected provides quantitative evidence for RQ3 about whether they feel school has influenced their decision to take science or not.

Question four is a multiple-choice item about the influences on taking science or not at post-16. The answers to this question will provide evidence for RQ2 about influences on decision-making as well as RQ3 about the role school experience plays in decisions to take science. This is a closed question involving a choice of six school

[25] The teachers giving the questionnaires out were given (verbal) instructions to allow students who completed the surveys to put them in a big brown envelope that would be sealed after the last questionnaire was collected. This would then be posted to the research institute.

influences on taking science or not taking science. These influences have emerged from the research literature to have an effect on student choice of science and students have a range of three choices about how much influence each had on their choice of science; 'A lot', 'some' and 'a little'[26]. One of the limitations of presenting prescribed choices in closed questions is that some people tick off more categories than they intend to in an open question. However, the prescribed choices are important as they reflect only 'school influences' whereas an open question would invite influences that are not necessarily school-based. It may be argued that perhaps the influence on science choice was not school-based and it is for this reason that there is a space for students to specify 'other' factors if they wish. It was acknowledged that some students would select a number of factors and that this would disproportionately distort the results. For this reason, students are instructed to put a circle around the one factor they felt had the biggest influence on their choice to take science or not. This would help elicit information about the biggest school influence on science choice without the need for applying weighting factors to all the answers.

Existing studies indicate that some students may have a preference for one or another of the three sciences. The final question asks student to indicate which science they liked best (if any) and state the reason why. This open-ended question will provide evidence for science subject preferences and why students like or dislike a particular science subject compared to another.

4.3.1.2 Phase 2: semi-structured interviews

Punch (2009; 144) states that the interview is a good way of accessing people's perceptions, meanings, and definitions of situations and/or constructions of reality. For this study, I wanted to listen to what students who had already made their post-16 decisions to take science or not had to say about how they made their choices. I also wanted to explore in greater detail the reasons students gave for the highest and lowest points in their storyline graphs. For this reason, I decided to use one to one interviews to probe further the influences cited by the students as reasons for their choice of science. A number of writers (e.g. Bryman 2008, Punch 2009) describe

[26] In hindsight, I should have included 'none' as well.

various types of interview in which there are varying levels of flexibility for the interviewer. The most flexible is the unstructured interview where the interviewer does not prepare any questions and uses the narrative to formulate and ask questions; while the least flexible is the fully structured interview where the interviewer does not deviate from the script. I chose to carry out semi-structured interviews so that I would have a small number of questions that I could ask in any order and also have the flexibility to follow up points that emerge from the students' comments.

The interview schedule (see appendix B) consisted of introductory comments followed by open-ended questions that could be asked in any order. The interview schedule was designed to take into account key points suggested by Bryman (2008; 251); avoiding general and leading questions, avoiding questions that are double-barrelled or include negatives and avoiding the use of long, complicated questions. There were a small number of questions in the original interview (see appendix A) but these were developed after the pilot took place (see 4.4 below) as I was interested in the students' points of view and in gaining rich, detailed answers; and I wanted students to have as much time as possible to voice their views. The questions designed for the semi-structured interviews can be categorised as:

Questions about context: The aims of these were to build up an initial rapport with the students and gain a general picture of their ideas about what school science is; e.g., what do you think is meant by school science? What subjects are you doing currently?

Questions about value of science: These questions helped me to understand how students looked at the value of science; e.g., in your opinion what is the value of science / should everyone at school learn about science?

Questions about school experience: These questions helped probe in detail the students' experiences of school science; e.g., did you enjoy school science / tell me about your storyline graph / did you feel the same way about all three sciences?

Questions about subject choices: these questions gave me insight into the reasons why students chose or dropped different subjects; e.g., how did you come to choose the subjects that you are taking now?

Justification of interviews as a research method

Although much of the information collected by means of an interview could be collected on printed questionnaires; the survey instrument is not able to collect the descriptive data needed to answer the research questions in a way that would disentangle some of the more problematic relationships influencing decisions to take science like school ethos. The role of the semi-structured interview in providing greater flexibility is already described above. In addition, the development of a personal relationship during an interview was more effective in eliciting answers rather than the impersonal method posed by questionnaires. For example, when a student found an interview question unclear, they were able to ask for clarification. It was also possible to scaffold questioning or probe deeper to tease out emerging issues.

An alternative approach to individual interviews would be to use focus group interviews. This consists of a group discussion focused on topics provided by the researcher (Gomm 2008). The method involves audio or video recording of the session for later analysis. An advantage of this method is the ability to interview a larger sample of students in a relatively short time. However, individual interviews provide extensive data and may offer a more accurate reflection of individual views as some individuals feel shy or insecure when talking about personal opinions in a group situation. A pilot test of this method showed that self-assured and confident speakers tended to 'hijack' the session and insisted on talking about their experiences silencing the more shy members of the group. The more self-assured and articulate students may dominate conversations, but it is the silent – or silenced – students that I also wanted to hear from to understand why some students disengage from science. It is also difficult to follow the line of conversation as individuals sometimes paired up to discuss points which meant three or four different discussions took place at once. This is overwhelming for the interviewer and results in voice recordings that are often inaudible and impossible to disentangle when transcribing[27]. Moreover, the influence of the students' views on each other is a problem when the object of the research is to

[27] I did try a focus group interview with a group of five students in one school where there were many students waiting to be interviewed and time was short. However, the recordings had to be discarded for the reasons mentioned.

discover what each student thinks or believes individually and independently of the others.

Limitations of interviews as a research method

Hollway and Jefferson's (2000) comment that narratives are a product of the relationship between interviewer and interviewee highlights the difficulties caused by the researcher's presence influencing the situation. An example of this is the problem faced during interviews about my role in the school; students wanted to know if I was 'one of them' (teachers) and despite assurances that I was a researcher carrying out a study in science choices, some students were still suspicious. In this case, I felt that they limited their responses and did not fully express their views.

Another problem in any type of interview is that the respondent may feel the compulsion to over-narrate to please the interviewer or under-narrate because it is natural for them to be shy, hesitant or silent. This is a risk inherent in any method of collecting information from a respondent, whether it is an individual interview, a focus group interview or a survey questionnaire. I tried to address this problem by making sure it was made clear from the outset that there were no right or wrong answers and that anything said in response to the interview questions would be confidential. I also carried out the interviews in as natural a setting as possible; on the school premises and during the school day.

The flexibility of a semi-structured interview puts greater pressure on the researcher to adapt the questions and their order and still make sure that all the questions are asked. Although I tried to work through the schedule of questions, it sometimes became difficult to follow the sequence when students started talking about related topics. Another problem also arose with standardisation of the questions asked of respondents. I tried to reduce the variability of questions asked of each respondent by making sure that I noted down all the sub-questions added and made sure to ask these in the other interviews. There is however a trade-off between standardisation of the interview questions and the chance to collect unique and interesting data. Also, some of the additional questions were specific to the case. For example, a female student who was interviewed said that her interest in science arose from a television programme and this led to further questions about which programme, which particular aspect of the programme as well as the main character who influenced her interest and why. These questions were not asked of any other respondent as no others indicated that they were influenced by a TV show.

Apart from the above considerations, interviews are a costly process, the time taken for each interview, the costs of transportation to interview venues, use of voice recorders and time taken for transcription all contribute to this cost. Interviews generate large amounts of data that need to be transcribed and analysed and some parts of the conversation may be of no value to the research project. It is a very labour-intensive method when compared to survey methods.

4.4 The pilot

The pilot study was carried out at an all-boys grammar school in South East England. An earlier version of the survey questionnaire was completed by 98 science and non-science students and 8 of these students were interviewed. The primary objective of conducting a pilot study was to trial the items in the survey questionnaire and the questions in the interview schedule. The secondary objective was to practise as a research interviewer and gain an understanding of the management of data collection. Carrying out the pilot was useful because it gave an indication of the time-frame involved in getting surveys completed and carrying out interviews. It also gave an idea of the time involved in collating survey data and transcribing interviews. This helped in an estimation of the number of surveys and interviews that could be realistically carried out in the two and a half academic terms allocated for data collection.

The pilot work was carried out with an early version of the survey instrument (see appendix C) that consisted of a single page with two questions. The survey data collected in the pilot made me realise that a lot of narrative content about the influences on choice was lost in the survey instrument because the students did not have enough time, space or inclination to explain their high and low points for each year at secondary school in detail. The instrument was revised so that students would explain only high and low points of the storyline graphs. In addition, it was realised that the data collected with the instrument did not provide enough evidence to answer the second and third research questions about influences on student decisions to take science and how school factors influence this choice, so more items were added that would enable this data to be collected. This resulted in a two-page questionnaire with four main questions. The revised survey instrument was tested with a sample of 25 students at a college of Further Education (FE). One minor change was made to question 4 on the suggestion of my supervisors; I included a range of choices – a lot, some or a little - that students could select to say how strongly specific school influences affected their decision to take science or not.

The data collected from the piloted interviews also highlighted ways to develop the questions in the interview schedule and as a result, the interview schedules were modified. More questions were added to the original schedule (see appendix D) to ensure that there would be enough data to provide evidence for all three research questions. Also, some contextual questions were added – e.g., what do you think school science is? – to help break the ice and start the interview instead of launching straight into the questions.

The pilot survey data also showed interesting features in the storyline graph trajectories. It was possible to classify the trajectories into four different types (described in 5.2.1). These trajectories could also be used as a basis for selecting which students to interview. For example, a non-science student with a gradually progressive trajectory in perceptions of science would be interviewed to find out why they had chosen not to take science.

The pilot interviews were carried out in an empty teaching room. However, other interviewees were present in the room waiting to be interviewed and I felt that some interviewees held back on information as others were ‘listening’. I also felt that later interviewees had been conditioned as they had a chance to hear the questions and the replies of the first interviewee and were able to formulate a response in the meantime. This highlighted that interviews should be carried out individually as there is some influence of another person being in the room. When planning the interviews for the current study, I specifically asked each school to provide a space so that I would be able to carry out interviews where students would not feel their conversations being intruded upon.

For each interview, I tried to follow the same technique consistently; I would start by introducing myself and the purpose of the study. I would then ask permission to record the conversation; once this was given I would switch the voice recorder on and then ask a preliminary question about which subjects the student was studying in sixth form. Once the student appeared relaxed, I would start with the first question in the interview schedule and let the student's response dictate the next question I asked.

4.5 Sampling

4.5.1 The schools

Due to the main aim of the study - investigating views of post-16 students' experiences of school science - I knew from the outset that I would only sample schools with sixth forms. My experience as a FE lecturer gave me an awareness that the intake in FE colleges is too varied to gain a view of school experience; e.g. mature students too far removed from their early schooling experience as well as students who have left or been excluded from schools. They would therefore not be a consistent sample population. My review of the literature also pointed out that I needed to take other factors into consideration about the selection of sample schools such as:

1. Coeducational – gender differences in response to school experience and science choices have been seen to influence students
2. Within or close to a city – there is some indication that urban and rural settings may provide different findings.
3. State maintained – personal experience indicates that the type of student in state and private schools may be different in terms of SES and parental background. To decrease variability because of this difference, it was decided to select mainstream schools.
4. Having a large sixth form with a range of subjects offered – a large sixth form would allow a large sample of students to be surveyed. Having a range of subjects offered ensures that the school is not limiting students' choices and that they can exercise their choice with suitable alternatives.
5. An equal mixture of science and non-science specialisms – review of the literature shows that specialist schools may affect the outcomes of student choices; therefore a range of specialisms would ensure a variety of science/non-science subjects.

After initial problems in gaining access into schools for the research study, I was able to negotiate access to seven schools; four located in urban areas of Surrey, one located in an urban area of Sheffield, one in London and one located in a semi-rural location in Yorkshire. Thus the schools to which I had access were not the purposive sample that I had planned. Each school that allowed access to interview the students was paid a small contribution[28] towards administrative costs and in acknowledgement of their help. Table 4.3 describes the characteristics of the schools involved in the sample.

4.5.2 The participants

Students in year 12 aged 16-17 years were an appropriate sample for this study because of two main factors. Firstly, these students have just crossed the transitional phase where they can choose whether they want to take up science or not and secondly because they are at the stage of their secondary school years where they are not too far removed from their school science experiences in lower school. There is another pragmatic consideration too; students in Year 12 are just beginning their A-level studies and are not usually in the intensely exam-oriented frame of mind that year 13 or Year 11 students (or their teachers) are found to be in at the time of year that the surveys and interviews were carried out. They are more likely to be available for the full three academic terms compared to final year students' availability for two and a half terms. Also, Year 13 students are a year further away from their experience of secondary school science choices and this may result in difficulty in remembering past experiences in lower school. Year 11 students are unsuitable as they will not yet have made their choice about taking science or not post-16.

There were two main categories of student type that this study sampled (see Chapter 1 page 18 for details) - scientists and non-scientists. This categorisation was developed further once the survey questionnaires were completed and analysed as discussed below (section 4.9).

I initially planned to carry out surveys on a sample of around 400-500 students as I felt that this would be a large enough sample to produce useful results but small enough to remain manageable for a single researcher in the time frame allocated for carrying

[28] Apart from the private school

out the research data collection – three academic terms. Of the sample of students surveyed, I calculated that I would be able to interview approximately 10% of students in the time-frame available. The students answering the surveys would be selected for an individual interview based on their science choices – whether they were taking science or not taking science in Year 12. I planned to interview equal numbers of males and females making sure that there are equal numbers of science and non-science students represented (see table 4.4 for details of sample). However, this was not possible due to a variety of reasons explained in 4.6.2.

Table 4.3 School characteristics of the participating school

School	C	R	G	E	SP	B	CL
No of pupils on roll	1909	1902	1463	1367	1192	1312	920
No of pupils on Sixth Form roll	410	311	234	227	237	107	250
Gender	Co educational	Co educational	Co educational	Co educational	Girls	Co educational	Boys
FSM	4%	3%	11%	8%	1%	11%	0%
School type	Maintained Comprehensive	Collegiate	Maintained Comprehensive	Maintained Comprehensive	Voluntary aided Faith School Selective	Maintained Comprehensive	Private Selective
School setting	Urban	Urban	Urban	Town and Fringe	Urban	Urban	Urban
Specialism	Language	Science	Maths and Computing	Engineering	Technology	Language	N/A

4.6 Implementation of the two phases of data collection

As mentioned above, the data collected for this study was carried out in two phases. The first phase was the survey questionnaire and the second phase was the interview. Below is a discussion of the two phases.

4.6.1 Phase I Questionnaires

After several weeks of negotiation with the schools, it was decided that I post the survey questionnaires to the contact person for distribution in the Sixth Form. In most cases, Year 12 form tutors would hand these out to be completed during form time. Sending the questionnaires by post, to be administered by the students' form teacher has limitations. Punch (2009; 249) highlights that respondents should be approached professionally and be fully informed about the purpose and context of the research as this ensures that people will cooperate and the quality of data is improved. He also emphasises the importance of the researcher to stay in control of the data collection procedure rather than leaving it to others. This was not an option in the case of the current study, the schools preferred to administer the questionnaires[29] with the result that it was left to individual schools to distribute the survey as and when they saw fit. One main limitation is the possible lack of adherence to confidentiality and anonymity procedures. For example, the schools distributed the questionnaires through Year 12 form teachers. These teachers are usually members of staff who have teaching responsibility in the sixth form and if the students are not reassured about the anonymity of their questionnaires, this may influence their answers. This problem is increased because the survey questionnaires are not anonymous and although it was stressed during the correspondence that no one should see the completed questionnaires but me, it is difficult to judge whether this was upheld by many of the individual teachers in the respondent schools.

Once the questionnaires were returned to me, a code number was assigned to each survey form and demographic details entered into an Excel spread sheet for that

[29] Usually because they did not want the additional logistical and administrative burden of inviting me in to administer the questionnaires. This worked well in some cases where they were able to target a large group of students in a number of sittings; but not so well where some schools took their time in administering the questionnaires and these had to be followed up many times. Alongside the limitations discussed above, posting the questionnaires back to the research institute posed a risk of loss in the post – as did happen with two batches.

school. The other items on the forms were coded by numbers and symbols to enable the information to be inserted into single cells on the spread sheet (see Appendix F).

4.6.2 Phase II Interviews

Interviews were conducted after the completed survey forms were received from the school. The survey forms were divided into science and non-science categories (see 4.5.2 above) and each category was classified on the basis of the storyline graph trajectories (see below and 5.2.1 for details). Although it can be argued that this categorisation of students brings about a selection bias; it is an unavoidable step of the process if I am to obtain data where male and female scientists and non-scientists can be compared according to their storyline trajectory. I tried to limit the bias by making it equally likely that an individual would be selected from their group by generating random numbers and selecting students from the number assigned on their survey form.

The trajectories of the storyline graphs are classified into four types – progressive, progressive with ups and downs (PUD), regressive and stable (see 5.2.1 for more detail). Based on these trajectories and the type of student (male/female and scientist/non-scientist) I drew up a list of names of students I wanted to interview in each school. I planned to see 16 students from each school based on the following criteria:

Table 4.4: the criteria for selection of students for interviews

Scientist		**Non-scientist**	
Male	Female	Male	Female
Progressive	Progressive	Progressive	Progressive
Regressive	Regressive	Regressive	Regressive
PUD	PUD	PUD	PUD
Stable	Stable	Stable	Stable

From the surveys, I found that in some schools there were not enough science students with a regressive trajectory or non-science students with a PUD trajectory; therefore I considered that it was best to interview students with either PUD or regressive trajectories for these schools. For those schools that had a number of these students with PUD and regressive trajectories, I would interview one of each.

The lists of students' names were sent to the schools and a process of negotiation was started to allow me access to the school for interviews. The first two schools on the list, gave me access to all the students I had indicated on the list. However, the main problem encountered was that the schools insisted I carry out interviews in a single day. As Punch (2009; 150) emphasises, time and location of the interviews influence quality of the data collected. So, although having to hurry through the interviews, the schools provided me with a room to interview in on the school premises and I was pleased to be able to carry out interviews in a quiet environment unlike some researchers (e.g. Morris, 2012) who report carrying out interviews in drafty corridors in hearing-range of other staff and passers-by. This constituted a trade-off where having to rush through interviews would affect the quality of the data negatively, having a separate room where both interviewer and respondent felt comfortable, would help enhance the quality.

A short time at the beginning of each interview was spent in explaining the project to the students telling them about the research background and making sure they understood that they could withdraw at any moment as well as refuse to answer any questions. The students were given the opportunity to ask questions about the study. This part was not recorded. After assuring them of confidentiality and anonymity the students were asked for permission to record the interview. At the end of the interview, many students asked me about university courses and the course requirements and destinations of these courses particularly in my research institution. These I answered to the best of my knowledge. This conversation was also not recorded.

The process of student selection for interviews fell awry at the second school. For various reasons, the school was unable to provide access to the students I planned to see; instead allowing me to 'pick' sixth form students from the common room. This posed a number of problems; first of all the sample would not be representative of the purposive sample I had compiled as students from the common room may not be representative of the types of students I wanted to interview – for example, what if science students tended to hang out somewhere else? Secondly, I would only be able to catch the more 'compliant' students adding further selection bias to the sample. This affected the quality and quantity of data as I no longer had matched student types.

The final two schools imposed their own criteria in providing the students I interviewed; one allowed me to interview those Year 12 students whose free periods coincided with the time I was at school for the interview and the other school gave me students that they thought were 'good' - who would turn up to the interview and answer questions properly. Again these school-selected students introduced bias to the sample; what if more of the 'good' students were non-scientists or what if they had a different attitude to science? It left me with an uneven sample of students – fewer female scientists. I tried to ensure a balance of male and female science and non-science students by carefully noting who was interviewed and asking for a particular category of student if I felt that this was missing. Sometimes, I recruited the student being interviewed into sending a friend of the category I needed to interview.

In all, I interviewed 53 students. Later advice came from the words of McCracken (1988) who contends that the first principle for the selection of respondents in qualitative research is 'less is more'. Upon reflection, it is more important to work longer and with greater care with few people than superficially with many of them. In hindsight, I perhaps should have limited my interviews to a half of this, and returned to these students for a follow up interview to clarify certain points that arose later during data analysis as this would have helped improve the quality as well as reliability of the data. Table 4.4 below indicates the number of students surveyed and interviewed from each school.

Table 4.5 The total numbers of students interviewed and surveyed and their categories

School code	Interviews				Surveys			
	Male		Female		Male		Female	
	Science	Non-science	Science	Non-science	Science	Non-science	Science	Non-science
C	4	4	3	4	16	37	19	51
R	4	4	1	3	41	5	23	6
G	3	6	4	5	13	9	12	13
E	4	1	2	3	15	28	15	27
B	0	0	0	0	19	21	9	23
SP	0	0	0	0	0	0	28	38
CL	0	0	0	0	64	30	0	0
Total	**15**	**15**	**10**	**15**	**168**	**130**	**106**	**158**

4.7 Ethics

From the outset of the research study, I was aware of the ethical considerations required by research that involves interaction with schools and school pupils; these ethical issues were informed by the vast amount of literature on research in school settings as well as research methods literature. Although it is not possible to address in advance all the ethical dilemmas that may arise, existing ethical guidelines from the University of Leeds School of Education Ethics Committee provided some reference points for acting ethically within the research study. I also adhered to the ethical code of practice outlined by the British Educational Research Association (BERA). Firstly, I applied for and gained ethical clearance from the University's Ethics Committee since my research involved surveying and interviewing minors aged 16-17 years. Then, a CRB was applied for through Sheffield Hallam University where I was registered as a STEM Ambassador and which allowed me to work in schools.

I wrote to schools with a letter of introduction in which I outlined my research plan in appropriate detail. Since the students I would be interviewing would be under 18, I sought permission from the school and took advice on whether I needed to seek permission from parents as well. I made sure that I obtained student permission to record interviews before starting each individual interview as well as giving assurance of complete confidentiality. I adopted the open democratic style of research (Scott 1996); allowing participants the right to refuse to participate further as well as being open about the study and its focus on science as a subject choice. I have taken steps to protect the participants from being identified in the reporting of data findings by anonymising school and student names by using letters or numbers. The names of students in the student profiles (see 7.3.1) bear no relationship to their real names.

My own background as a teacher and a parent makes me aware that time at school is limited and I did not want to waste student time to answer my questions for the benefit of my research. To ensure that I did not encroach upon their study time, I asked that survey forms were completed during form-time and that the interviews only occurred during the student's 'free' time.

The main ethical issue that arose within the survey questionnaires and in interviews was when students named and/or criticised their science teachers. I had not intended that the surveys or the interviews encourage students to do this but a number of students reported their like or dislike for their science teacher by naming them. I resolved this issue by making sure that in the reporting of data there is no mention of the teacher as an individual and the anonymity of the school and student means that comments made about poor teachers cannot be traced back to any particular school.

4.8 Data analysis

Bryman (2008) recommends that the researcher should be fully aware of techniques of data analysis to be applied early on when designing the study. This is so that decisions such as which kind of data to collect and the size of the sample can be decided early on as well as the techniques to be applied such as questionnaire design. It is also important to make sure that the research aims are going to be met effectively and decide which method of analysis will be most appropriate to answer the research questions. Although I had an idea of the general methods of qualitative and quantitative data analysis, I found I had to adapt my methods to the data collected from both surveys and interviews.

Although a significant element in the analysis aimed towards quantitative reporting of students' views and responses, its ultimate goal was to offer a more qualitative conceptualisation of the place of school science within students' post-16 choices. To achieve this the approach resembled that associated with what is often called 'grounded theory', though without seeking to use the full apparatus which Strauss and his colleagues developed (Strauss & Corbin 1997). In particular the shift towards broader concepts is not to be understood except in the broadest sense as inductivist, but rather as a critical yet creative approach. By using such an approach, I was able to interpret the data to find out what students conveyed about their experiences of school science and their role in the decision-making process and to offer a broader conceptualisation of it. This helped uncover the relationship between experiences of school science and the decision to take up science or not post-16. The process of analysis was begun by sorting the data into categories. To help capture the conceptualising, examining and categorising that went on during the initial phase when data was read and re-read, I engaged in memo-writing in which I put down thought that related to codes or emerging concepts (see 4.8.1.2 below for detail). This procedure helped in the constant revision of concepts that emerged from survey and interview data as the study proceeded. Some concepts had to be modified during the analysis period. Theorising was guided by exploration of what was found in the data so that some sections of prose were coded and re-coded as analysis proceeded and data were reconsidered in the light of emerging concepts or patterns.

Below follows an account of the data analysis methods used to analyse survey and interview data.

4.8.1 Survey questionnaire data

Once the completed survey forms arrived, they were counted and checked to make sure that they were legible and valid. Invalid questionnaires – those missing demographic details or storyline graphs – were discarded. Then the survey forms were assigned numbers and the demographic information for each was entered into an Excel spread sheet for that school. The survey forms were then divided into two categories – science and non-science (based on whether the students was doing one or more science A-levels or not). The storyline graph details were entered on the spread sheet for each year that was marked on the graph. The graphs were also allocated a type (see section 5.2.1) that was entered into the spread sheet. Information about the time of influence and the influences on science choice were also entered into the spread sheet. Where students had indicated the biggest influence on their decision to take science, this was also entered. This was followed by the school influences to take science or not. The biggest influences were also entered for those students who had circled their choice. The data for surveys with more than one choice of factor for this question were not entered.

From the survey forms it was seen that most students who had completed the final question which asked whether they felt the same about all three sciences, either answered ‘yes’ or wrote down which science they preferred and this data was considered to be quantitative. However, many students in one school (SP) wrote comments about why they had chosen their particular science subjects and these were treated as qualitative data. The data from the question about high and low points was treated as both quantitative as well as qualitative data and its analysis is discussed in the sections below.

4.8.1.1 Quantitative analysis of survey data

The survey data collected and entered in the spread sheet described above consisted of mostly quantitative data. The research questions in this study rely on the insight and depth of qualitative data analysis as well as the numerical findings of quantitative data analysis. The quantitative findings have a role to play in highlighting trends and patterns but have a supportive rather than an explanatory role. The table below summarises the methods of quantitative data analysis for each of the items on the survey questionnaire.

Table 4.6 Quantitative data analysis methods to be used to analyse survey questionnaire data

Item	Data analysis method	Where to find
Q1 Storyline graph	Mean – to show average points for each year for scientists and non-scientists Median – to show middle value ignoring extremes at either end Frequency tables for each type of trajectory per student type	**Chapter 5** **Section 5.2**
	Single factor ANOVA to find statistical difference between trajectories and science A-level take-up	**Chapter 7** **Section 7.2**
High and low points of storyline graph	Frequency table of statements	**Section 5.3**
Q2 When did you make a firm decision to take science or not?	Bar graph to show differences between scientists and non-scientists	**Chapter 6** **Section 6.2**
	Cumulative frequency graph showing differences between the two types of scientists	**Section 6.2**
Q3 Do you think school science has influenced your choice whether to take science or not in the future? YES / NO	Frequency table to show difference between scientists and non-scientists.	**Chapter 7** **Section 7.2.1**
Other influences	Descriptive percentages	**Section 7.2.1**
Q4 Table of school factors influencing decision to take science or not.	Frequency table of percentages Chi square test for statistical significance of ratings that students give each factor	**Chapter 6** **Section 6.3**
Biggest influence	Multiple regression analysis	**Section 6.3**
Is the influence the same for all sciences?	Absolute counts Frequency table	**Chapter 5** **Section 5.4**

Reporting descriptive statistics such as percentages and frequencies is the first step in quantitative analysis of data. The main advantage of this is that the findings are easily interpreted. Frequency tables were used to give a picture of how many students have responded to each factor. Chi-squared tests were used to report the statistical significances between some variables (see table 4.6 above). Although there was no intention of using multiple regression analysis or analysis of variation before data collection, these statistical measures were used to clarify effect sizes in the data when the need arose[30].

4.8.1.2 Qualitative analysis of survey data

The qualitative data from the survey arises from Q1 about high and low points in the storyline graph and Q5 in which students explain their biggest influences and whether it is the same for all three sciences. I used a procedure adapted from Willms and Johnson's (1996) work on how to carry out content analysis on text (see Appendix E for detail). Twenty survey forms were read and re-read to set up codes[31] (see Appendix E) for the low and high points of the storyline graphs. Once the codes were established, another 20 samples were checked against the codes; the codes were adjusted to include more codes. Then another 100 survey forms were read and re-read to combine or add to the list of codes. Finally another 40 survey forms were coded and when it was seen that no more codes were to be added, the existing rough codes were collapsed into final codes which were used to code the remaining surveys.

Once the final bank of student responses was established and comments exemplifying these were included, the final codes were collapsed into themes. These themes characterised all the comments from the surveys about positive and negative experiences of school science (see table below).

[30] This is why the data collected was not in a form that would lend itself easily to this kind of statistical analysis.

[31] For example, enjoyment, boring, challenging etc.

Table 4.7: Examples of comments for each coding category for high and low points

Themes	Exemplar comments included in the coding categories	
	Low points	**High points**
Teachers/ teaching	Bad teachers, ineffective teachers, didn't like teacher , named teachers, poor teaching, not enough help provided, didn't like teaching style, absent teachers.	Good teacher, liked teacher, fun teacher, named teachers, good teaching
Curriculum content	Too much science content, didn't like topics, repetitive, limited topics, too much information, topics not interesting, too simple, no challenge, learning facts, slow, no depth, too much theory. Not enough practicals	Exciting topics, new topics, more detail, engaging topics, interesting topics, more depth new things, challenging Lots of practicals, named practicals, fun practicals
Perception of science	Huge workload, hard, increased stress, learning for SATS/ tests / exam pressure, not confident, not good at it, didn't understand, confusing, difficult, too complex, too serious, exam-focus.	Easy, understood science, no exams, less focus on exams, started to understand, confident.
Interest /enjoyment	Science is boring, not interested, science wasn't interesting, not fun, not bothered, didn't like science, was bored	Enjoyed it, exciting, fun, enjoyable, preferred the course/subject, liked science,
Classroom environment	Disruption from others, disruptive classes	Liked classes, more time to learn
Attainment	Poor grades, got low grades, in low set, moved down a set, didn't try hard, didn't concentrate	got good grades, in a higher set, moved to higher group, more dedicated to it, wanted to do well, worked hard

Collapsing and combining categories was problematic in some cases; e.g., the decision to keep 'difficulty of science' separate or to combine it with 'curriculum content' or 'perception of science' took many months of deliberation and resulted in re-analysis of the data several times. Reading and re-reading of the scripts seemed to highlight that students 'perceive' science to be difficult and that this is better allied with perceptions of science rather than with curriculum content which students wrote about as being repetitive or having too much theory.

The following table indicates the decisions taken about particular features of the student experience arranged around the themes arising from table 4.7.

Themes	Examples of decisions taken
Teachers/ teaching	This category encompasses both what students said about their teachers' personality as well as their pedagogy e.g. if they used powerpoints or made students take notes from the book or the board. I judged pedagogy to be related to the professional judgement of the teacher rather than a domain of Curriculum content. In some cases, students named their teachers and this was also recorded as a point; if the name was in the high points section, then it was recorded as a high point. There were some decisions that needed to be made as some of the points could be argued to belong to either Teachers/teaching or to Curriculum content such as 'too slow'. In this case, the student was interviewed and he made it clear that he was talking about the repetitive nature of the content rather than the teachers' way of teaching. Inevitably this and some other issues were essentially judgemental, reflecting the overlapping relationship between teachers, teaching and curriculum content, and the impact of teachers ' own professional perspective. In this domain and below, particularly problematic cases were discussed with supervisors.
Curriculum content	These statements included all the points students made about the curriculum or subject content such as being repetitive, being exciting or new. There was also some overlap with the category of interest where students talked about interesting topics. These were noted as points in curriculum content rather than interest since they were about the content of science topics and being interested in these rather than a general interest in science. In earlier analyses of the codes, science experiments (or 'practicals' as students and teachers commonly call them) were kept separate from this category. However, in later analyses informed by interview data it was decided to incorporate science experiments into curriculum content as this is what student discourse pointed to – that science is a subject that involves science experiments. Subsequently, any phrases used by students indicating practicals being interesting or fun were recorded as a point for

	curriculum content rather than in the category of interest/enjoyment because they specifically mention practicals. Again, it must be acknowledged that this is a judgement which others might have called differently.
Perception of science	Perceptions of science has some overlap with curriculum content too; any statements that students made about the stress or pressure they felt from science at school were taken to be perceptions of science and not just about the specific detail of curriculum content. Though it could be argued that these statements should be part of curriculum content; however, I felt that perceptions of science had a greater relationship with self-efficacy and as such, should encompass all statements that students feel about their relationship to school science such as not being confident or starting to understand.
Interest /enjoyment	Interest in science included statements made about the general subject of science rather than specific topics. So statements such as being bored with or not enjoying science were counted as low points and where students mentioned enjoying or preferring science, these were counted as high points. References to interest in particular topics such as 'disease' were counted as Curriculum content.
Classroom environment	Classroom environment was not included in the Teachers / teaching category because a significant number of students indicated that disruption from other peers in the classroom was a cause of negative experience of school science and it was felt that this should be separated from teacher effects to prevent distortion of the results. Although in the interviews students sometimes blamed teachers for not managing classroom environments, this was not the case in the surveys where respondents pointed out that their low points were because of disruption in the class.
Attainment	Attainment included all the statements made by students about their grades or the sets that they were in for science. It also included isolated comments such as not trying hard or wanting to do well in science. It was decided not to categorise these comments as perceptions of science as they do not indicate a general response to science but rather a behaviour pattern.

Once the above six themes were established, the survey forms were read again to make sure that the comments about the high and low points of school experience were coherent and conveyed fully what the students were reporting[32]. To ensure validity of the themes, an audit check was conducted to check the suitability and strength of the themes that had been developed from the coding categories. My two supervisors were given high and low statements from the survey forms to sort into each theme. Their categorised statements strongly agreed with and confirmed my own.

Once all the themes were established, each was designated a code number which was entered into a spread sheet for simple quantitative manipulation.

4.8.2 Interview data

The broad guidelines to a general inductive approach to qualitative analysis of the interview data suggested by Thomas (2006) informed the approach taken in this study (see Appendix F for details of this process).

4.8.2.1 Qualitative analysis of interview data

The audio recordings of the interviews were transcribed (see Appendix F for an exemplar transcript) and read to gain familiarity with the content and gain understanding of the details in the script. Ten transcripts were read and re-read to identify categories from actual phrases in the text. These categories were noted and a further ten transcripts were read to check if the categories needed to be added to and which ones could be collapsed (see appendix F for details of the categories). This was repeated with another ten transcripts until data saturation. The categories were entered as nodes into NVIVO 8 into specially created projects per school. From reading and re-reading of a full interview transcript, the next step was to identify the text that would fit under the specific categories. The program allowed interview transcriptions to be imported as text files which were manipulated into sections allowing the matching of segments of the data to the categories. The categories were used as codes (see Appendix F for an example of how the transcript was coded). An example of how this process was carried out is given below (box 1).

[32] In the survey questionnaires, a majority of student (75%) write a single reason for their high/low points while others write two reasons for each. Very few students (n=3) wrote three reasons for high/low points.

Box 1

An analysis of the response to the question ‘describe why you think your teacher was good’: G4 MNC gave the response: *In Year 9 and 10, I had a teacher who made science really interesting and he was really interesting…even though we were doing coursework in year 10 and we had him, it was just much more interesting. It didn’t seem as much tedious.* This response was considered to contain two different meanings and was therefore assigned to two different nodes that related to two different categories. The first text segment of meaning *I had a teacher who made science really interesting* fit into the category ‘teacher pedagogy’. The second text unit of meaning was determined to be *he was really interesting* – this text segment was considered to fit into the category ‘teacher personality’. Thus this statement was analysed as containing two separate coding categories.

The master transcript was read again for sense and to review and revise the categories. This was repeated with a second transcript and new categories were added to the list while some were collapsed to form a single category. This process was repeated until all the transcripts had been read and the emerging categories identified. Once the categories were established, decisions were made to collapse categories into themes. An example of how the categories were combined is seen below (box 2).

Box 2

Once the initial categories were collapsed to combine or link to emerging categories, they were grouped under a theme where the meanings seemed to convey the core theme or essence of a category. Thus the initial categories were reduced to 7 themes that emerged from some of the smaller categories being merged with similar and allied categories and larger categories split up and merged with similar categories. For example, two of the initial categories that emerged from the text were labelled as ‘teacher pedagogy’ and ‘teacher personality’. However, it became quite difficult to fit some text units neatly into these categories. Students would talk about teachers and their method of teaching in one text unit. Therefore a more meaningful category that reflected the sense of the data seemed to be combining the two categories into one; the theme ‘teachers’ retained the meaning of the text. This was checked with other transcripts to make sure that meaning of the text units was retained.

The comments were then divided into two groups – one about school science experiences and the other decisions to take science or not. The consistency of the data analysis was checked with colleagues by having them allocate text units from a transcript to the themes; this confirmed some of my decisions and helped me to change some of the groupings of emerging categories. For example, the decision to combine science experiments with curriculum content.

Finally, the relationships between the themes were identified through a taxonomic analysis. Onguwebuzie, Leech and Collins (2012:18) draw on Spradley's definition of taxonomic analysis as the use of a flowchart or other graphical representation to organise different domains or categories in relation to each other. This approach is reported in their paper on qualitative analysis techniques and has been adapted to suit the data available in the current study; the six themes were grouped in different arrangements to identify if the theme is itself a subset of another theme (for example, practical experiments and curriculum content) and to collapse the number of themes emerging from the data to a smaller number of factors. This resulted in the identification of three factors (see Figure 7.3). Re-reading the transcripts having identified these three factors helped to identify information that was missed the first time.

Thus both these approaches – Thomas' general inductive approach and taxonomic analysis were used to make sense of the data. The hybrid approaches helped to develop themes and factors emerging from the raw data which were then analysed and described in the findings chapters.

4.8.2.2 Quantitative analysis of the interview data

Using Nvivo software helped in quantifying qualitative data. The frequency of comments for each code was counted to compare e.g. how many times scientists talk about good teaching in their school science experience in comparison to non-scientists. Silverman (2010: 276) describes how qualitative studies can sometimes be subject to criticisms of 'anecdotalism' where researchers may depend on a few well-chosen examples of findings to support their argument. To guard against accusations of anecdotalism, I employed simple counts of the categories that I found in the interviews and reported these along with the qualitative data (see tables 5.5 and 5.6).

4.9 Limitations of self-reported data

In this study, self-reporting presented a particular challenge because the storyline method required respondents to report their experiences from the past six years of school. In addition, they were asked to condense a whole school year into one data point on the graph. Although the main advantage of survey and interviews is that it provides the students' perspectives of their experiences, data of this kind can be limited because it is self-reported. The main disadvantage to self-reporting is that it is difficult to validate the data. In other words, the students may deceive intentionally or unintentionally by forgetting or fabricating details; particularly when asked to report on experiences further away from the current time. One way to counter this problem is to seek the view of someone who knows the student and who is familiar with the student in their natural setting such as a teacher. However, in this study it was decided not to enlist teachers as informants. The aim of the study is to explore student experience of science and it is assumed that teachers would not be able to validate their students' feelings. The data narrated by the students will be personal to them and may not match the views of reality held by the teacher.

Barker, Pistran and Elliot (2005) highlight the two main arguments that cast doubt upon self-report data; one is the limit to an individual's conscious self-knowledge and the other is a bias in the way and individual accounts for their behaviour. Although these limits are important to bear in mind, it does not mean that all self-reported data is unreliable. In this study the self-reported data from surveys is triangulated and supported with interview data. In the interview, questions about experiences were used to check for inconsistencies between interview and survey data[33]. Students were not given their previously completed storyline graphs to look at in the earlier part of the interview and had to recount their experiences from memory. In the majority of cases, there was a consistency between the students' accounts and the storyline graphs of their experiences.

4.10 Reliability and validity of the research instruments

Textbooks on research methodology (e.g. Bryman 2010) emphasise the importance of validity and reliability in qualitative research. It is important to note that both terms have distinct meaning; validity relates to whether the construct intended on being measured using the survey and interview is actually being measured while reliability refers to whether the data collected is consistent. Above it is discussed that self-report data is not easily or reliably cross-referenced and so may be prone to problems of interpretive and observer bias. In an effort to

[33] For example, can you remember when your high points were in your school science experience?

address this, I describe below the ways in which I triangulated my findings in response to these concerns.

Firstly, to consider whether my data was valid, I tried to make sure that the constructs I used in my interviews were understood and shared with students to avoid misunderstanding, misinterpretation and vagueness. For example, students were asked to identify the subjects that they thought constituted ‘science’ on the survey questionnaire. During the interview, they were asked to clarify what they thought was meant by the term ‘science’. Students were also asked about their understanding of various concepts such as ‘the way science is taught’ to ensure that I did not misunderstand their view of the concept.

Secondly, to ensure that there was adequate reliability in what students actually said and did, I took care to make field notes and observations at the time of interview. I would often ask a student to expand when their meaning was unclear or would rephrase their answer to test my interpretation of what they were saying.

Thirdly, I was aware of observer bias when interpreting interview data. To address this issue, I planned on checking my interpretations with the students. However, the lack of time and the challenge of contacting students at their schools were two factors that prohibited this ideal; instead, I cross-checked my data with evidence from data with similar studies (e.g. Lyons 2006) and found that the general categories described by the students in this study were similar to those in comparable studies.

Fourthly, to check for representativeness of data, I interviewed all categories of informants to get a complete picture. Alongside students doing A-levels, I also interviewed students doing BTEC in science and non-science subjects.

In the pilot study described in section 4.4, I explain how I got feedback from the students to improve the quality of the study design in terms of questions asked in the survey questionnaire and interviews. It would have helped improve both validity and reliability of the conclusions if I could get similar feedback from students after the analysis of data; however, this was not possible in the time allocated.

4.11 Emerging student types

From both survey and interview data emerged a further number of student types apart from the two main categories described above – scientists and non-scientists.

Firstly, from the survey questionnaires, it was possible to develop further categories of scientists by looking at the number of science A-levels taken and considering the answer to the question whether students planned to take science at university or not. Scientists could be categorised on the basis of these two variables into scientists who were definitely going to take science in the future (future scientists) and those who may or may not take science in the future (potential scientists). The following table illustrates the way the group of scientists were distinguished:

Table 4.8 The criteria for distinguishing between future and potential scientists

No of science A-levels taken	**Are you taking science at university?**		
	Yes	***No***	***Don't know***
1	Future scientist	Potential scientist	Potential scientist
2	Future scientist	Potential scientist	Potential scientist
3	Future scientist	Potential scientist[34]	Potential scientist

Secondly, from the interview data, it was possible to distinguish two further categories of non-scientists:

- non-scientists by choice
- non-scientists by exclusion

This final category is derived from Pike's (2008) PhD study of student students' choices to take science or not. The interview data showed that non-scientist narratives about their choice not to take science at A-level were of two types. One type of narrative showed that the non-scientist made a decision not to take science because of other factors such as a lack of interest in science, or because they had a career choice that did not involve taking science – the non-scientists by choice. The other type of narrative identifies non-scientists who would have liked to take science because they liked it or wanted a science career but were not able to take it up because of their poor examination grades in GCSE science which precluded them from taking science further – the non-scientists by exclusion.

[34] Although the student has indicated that they will not be taking science at university, having chosen A-level science makes them a potential scientist since they seem to have the ability to be a scientist if they chose.

The findings chapters following will use either the two original categories or the four categories of students according to the findings being discussed. This will be made explicit at the start of each chapter.

4.12 Reporting the findings

The next two chapters (5 and 6) report the findings for RQ1 and RQ2 respectively. Both chapters start with a quantitative analysis of the findings followed by qualitative findings and supporting evidence from student comments from survey and interviews.

Where student comments are reported, they are followed by a letter and numbers which help identify which school they are from, what gender they are and what student type (discussed above). An exemplar table of codes is shown below:

Table 4.9 Exemplar table of codes for survey and interview comments

Code	Meaning
E4 MSF	School E male future scientist
R12 FNC	School R female non-scientist by choice
C13 FSP	School C female potential scientist
G3 MNE	School G male non-scientist by exclusion

Chapter 5 Students' views of their school science experience

5.1 Introduction

The main aim of this study is to gain an understanding of how students experience school science and which influences they view as significant in their experiences. This chapter will present findings from both survey questionnaires and interviews that provide evidence for RQ1:

What are students' views of their school science experiences?

This chapter will discuss findings in terms of the two main types of students – scientists and non-scientists (see Chapter 1 page 18). The aim is to examine the differences between scientists and non-scientists and to paint a picture of student responses as a whole; where there are significant findings emergent in the two different types, these will be identified.

To gain a general view of student experience of school science, the first section describes quantitative findings from the storyline graph. Then in order to provide depth to the quantitative data, the following section describes qualitative findings from both survey and interview data about high and low points in student experiences of school science. The final section describes student experience of the three science subjects.

5.2 Student experience of school science - quantitative findings

The items on the survey questionnaire that help provide evidence for this research question are the storyline graph and its associated question about the high and low points of students' school science experience.

In this study, there are two assumptions associated with the storyline graph; firstly, since it has been used as a tool for reflection on events in the students' experiences of school science, **points placed on the storyline graph are assumed to be important events** in the school science experience of students. These may explain which factors play an important role in experience of school science. Students write about the incidents as reasons for the high and low points placed on the graph and this will help to unpack the factors that students perceive as important in their views of school science. The second assumption is that the **trajectories of their graphs reflect students' experience of school science**. Thus, the trajectories tell the stories of each individual student's experience (discussed in the section below). The commonalities of scientists' and non-scientists' graphs will make it possible to piece together an overall picture of students' experience of school science from different perspectives.

In the section below, the types of storyline trajectories are detailed; this is followed by an examination of student experiences in individual years. Finally the reasons that students give for their high and low points in the survey questionnaire will be discussed.

5.2.1 Storyline graph trajectories

Nilsson and van Driel (2011) in their use of the storyline method with student teachers, describe four types of graph; progressive constant, progressive with ups and downs, stable and regressive. Based on the storyline graphs from the completed surveys, the graph types suggested by Nilsson and van Driel were developed into further categories reflecting the types of trajectories the students in the current study drew. The four trajectories are:

1. Progressive (P) in which the student has indicated that their experience of science has improved over the years spent at school.
2. Progressive ups and downs (PUD) in which there are ups and downs over the years but ends the same as or more positively than the start[35].
3. Stable trajectory (S) is one that does not fluctuate – it can be high, low or neutral
4. Regressive trajectory (R) is one in which there is a downward trend in opinion of school science.

These four types of trajectories are not exhaustive as there are a number of possible variations to each trajectory; particularly in the case of a PUD trajectory[36]. However to

[35] For example, if the trajectory starts at 3, then goes up and down but ends at 3 or higher, it will be a PUD trajectory.

[36] Some PUD trajectories start very low and increase slowly to a positive only to decrease again to a negative; others start high, become low and then become high again. In other words, there is a great diversity within this category of trajectories.

keep the number of trajectories manageable, it has been necessary to collapse the number of possible combinations. For more details and examples of the storyline trajectories, see Appendices G & H. As explained above, the assumption is that P trajectories are indicative of a positive experience of school science while a PUD trajectory indicates a more varied experience with highs and lows occurring at different times in secondary school experience. The R trajectory indicates a less positive or a negative experience. Students with stable trajectories are those who believe school experience of science has been more or less constant.

The trajectory categories were checked by two colleagues and the placing of particularly problematic graphs into one of the four categories was discussed to reach a consensus. Agreement of trajectories being placed in one of the four types of graph was consistently high.

The table below indicates the absolute numbers and percentages of the four different storyline trajectories of students who have chosen to take science (the scientists) or not to take science (non-scientists) post-16. As explained in the previous chapter (section 4.5.2), scientists are students that have taken at least one science subject at A-level and non-scientists are students that have not taken any science subjects at A-level.

Table 5.1 Table showing the storyline graph trajectories according to student types

Graph types	**Student Types**		
	Scientists N=274	Non scientists N=283	All students N=568
P	122 (44%)	77 (27%)	199 (35%)
PUD	62 (23%)	56 (20%)	118 (21%)
S	29 (11%)	45 (16%)	74 (13%)
R	59 (22%)	118 (41%)	177 (31%)

P = progressive, PUD = progressive with ups and downs, S = stable and R = regressive.

From Table 5.1 the general pattern shows that the largest group of students have a P trajectory; in other words, it can be said that overall more than a third of students surveyed have a positive experience of school science. However, the number of students with a regressive trajectory is also quite large. Overall, a third of the sample have had a negative experience of school science. Of the remaining students, a larger number have had a variable experience and a smaller number have had stable experiences (i.e., the experience of secondary school science has been quite similar from Year 6 – Year 11).

Looking at the pattern of trajectories for the two different types of students – scientists and non-scientists, it is seen that generally scientists have more P and PUD trajectories (67%) than non-scientists (45%). Almost twice the number of non-scientists have regressive trajectories compared to scientists. Testing for significance of these findings with a chi square test (see Appendix I), it is seen that there is a statistically significant difference between scientists and non-scientists with P and R graphs (both $p<0.001$). In other words, significantly more scientists have progressive trajectories compared to non-scientists and significantly more non-scientists have regressive trajectories than scientists. However, a counter-intuitive finding emerges in that 22% of scientists have a regressive trajectory and 27% non-scientists have a progressive trajectory. This will be examined in more detail below.

From the table above it is seen that some students (n=74) surveyed have a stable trajectory; this kind of trajectory implies that a student with this trajectory has had a constant perception of school science during their five years at secondary school. The 74 stable trajectories can be further split into three types – high, low or neutral – depending upon where the students have drawn them on the storyline graph. High stable trajectories are the ones drawn at points 4, 5 or 6 on the graph; neutral stable trajectories are drawn at 3 while low stable trajectories are drawn at points 0, 1 or 2. Table 5.2 below shows a comparison of the types of students according to the stable storyline they have drawn.

Table 5.2: A comparison of stable trajectory types of scientists and non-scientists

Stable graph types	Student Types		
	Scientists N=29	Non scientists N=45	All students N=74
High	20 (69%)	17 (38%)	37
Low	1 (0.03%)	12 (27%)	13
Neutral	8 (28%)	16 (36%)	24

When comparing stable trajectories it is seen that a large number of scientists have a high stable trajectory and relatively fewer with low and neutral trajectories; non-scientists generally have similar numbers of high or neutral trajectories and relatively fewer with low stable trajectories. A chi-square analysis (see appendix J) reveals that there is no significant difference between scientists and non-scientists with high trajectories. There is a significant difference between scientists and non-scientists with low trajectories; only one scientist has a low stable trajectory compare to twelve non-scientists.

5.2.2 Student experience of school science – the individual years

Looking at student experiences of school science; the data from the storyline graph not only gives a general view of their experiences over the past six years of school science but can also provide insights into the patterns across individual years. In this section, the student experience of each individual year is looked at in more detail to better understand the overall patterns.

The table below breaks down the details of the years spent in secondary school to find out how the two different types of student feel their experiences of school science were like in individual years at secondary school.

Table 5.3: The average points for each year at school for both scientists and non-scientists

Student perceptions of school science during secondary school						
	Year 6	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**
Scientists N=274						
Mean	3.7	3.7	3.7	3.8	4.0	4.6
Median	3	4	4	4	4	5
SD	1.5	1.3	1.3	1.4	1.6	1.7
SE	0.08	0.08	0.07	0.08	0.09	0.1
Non-scientists N=283						
Mean	3.3	3.3	3.2	3.1	3.1	3.1
Median	3	3	3	3	3	3
SD	1.6	1.5	1.4	1.3	1.4	1.3
SE	0.1	0.09	0.09	0.08	0.08	0.08

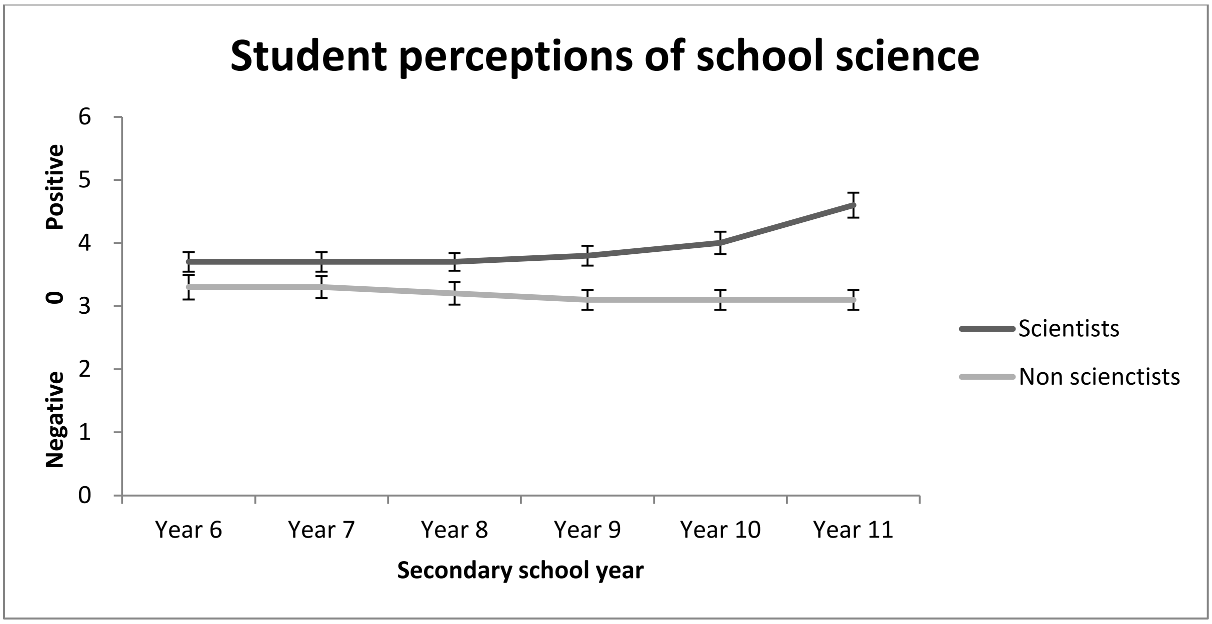
standard deviation (SD) and standard error (SE)

From the table above, the average points for storyline graphs show a difference in the perceptions of school science between scientists and non-scientists. Scientists' experiences are slightly more positive than non-scientists with an increase in positive experience after Year 9 and another increase in Year 10 with a larger increase in Year 11. In comparison, non-scientists' perceptions at the beginning of secondary school are slightly less positive and stay that way throughout their secondary school years.

The graph illustrating these tendencies (see graph 5.1 below) shows clearly the difference in trajectory between science and non-science students. It highlights that school science experience on average does not fall below neutral. This shows that most students surveyed in this study generally have a fairly neutral experience of school science; however individual graphs paint a different story as seen in the graphs in Appendix H.

The SD of the mean values are relatively large as the mean takes into account the whole range of student responses; in this case it is useful to look at median values narrower range of student responses to their experience of science in each school year. The median value ignores the range of data particularly the more extreme results at the two ends (points 0 and 6). The median values in this case for both types of students show the same pattern as the mean values; scientists have an increasingly positive experience of school science while non-scientists experiences remain stable throughout secondary school. There is a slight deviation from the mean values of scientists that show positive experiences increase in Year 9; but taking the median into account, the positive experiences seem to increase in Year 7. Examining the position of the SE bars for each mean will help in understanding whether we can be confident that Year 7 is the time when scientists have an increasingly positive experience of school science.

Figure 5.1: the experience of science and non-science students in each year of school with standard error bars



The non-overlapping SE bars from Year 7 onwards indicate that there is a significant difference between the perceptions of scientists and non-scientists at the 95% confidence interval levels (see Appendix K for more detail). On average, from Year 7 onwards scientists have a progressively positive trend in their perceptions of school science while non-scientists keep a slightly lower but stable trend in their perceptions of school science. Research into attitudes of secondary school students towards science reports a dip in attitude from Year 7 that continues into Year 9 (Barmby, Kind and Jones, 2007). These findings do not reflect this claim; instead showing that for some students in this sample, the experience of school science becomes more positive in Year 7 while it remains more or less similar to previous years for others.

The storyline graph low and high points are probed in more detail in the qualitative analysis of survey and interview findings about school science experience below.

5.3 Student experience of school science - qualitative findings

This section integrates the qualitative findings from the survey and interview data about student experiences of school science. It starts with a brief discussion of the high and low points of the survey data and is followed by two sections; one integrating the survey and interview data for aspects of the low points that students felt about their school science experiences and the other, the different aspects of their high points.

5.3.1 Low and high points in school science experience

From table 4.7, it is noteworthy that students comments about the high and low points of their school science experience can be represented by a single theme; e.g., curriculum content is a reason for both high and low points. Thus, each category has a binary quality; there are no themes that arise for just high or low points. For example, curriculum content is the reason for a high point for one student because of engaging topics but a low point for another student because the topics are too boring. Some students wrote their high/low points as polar dimensions (e.g., a good teacher as the reason for a high point and a poor teacher as the reason for a low point); but the majority of students wrote different reasons for their high and their low points (e.g., curriculum content as a high point and classroom environment as a low point). Therefore, students experience a variety of reasons for their high and low points and that it is not just absence and presence of any single factor that influences school experience of science.

5.3.1.1 High points in school science experience

After the coding of student responses to high and low points in school science experience, the codes were entered into a spread sheet to be quantified and analysed. Table 5.4 below shows the frequency of student responses and their reasons for high points in order of number of survey responses.

Table 5.4: Reasons for students' high points in secondary school science

Reasons for high points	No of survey responses n=485[37]
Curriculum content	180 (37%)
Interest / enjoyment	106 (22%)
Teachers/ teaching	103 (21%)
Perception of science	41 (9%)
Attainment	31 (6%)
Classroom environment	15 (3%)

Curriculum content is the most quoted reason for high points in school experience of science for this sample of students, whereas interest in science and teacher influence are roughly similar in the times they have been mentioned as high points. Perception of science and attainment are less frequently quoted as a high point. These five main aspects are described below in more detail. Classroom environment exemplified by comments such as *I liked the class I was in* is not as significant as the other aspects; it is decided that any aspect having less than 5% student comments will not merit discussion.

Where there is a change in balance of comments over the range of secondary school years for each of the reasons described below, this will be discussed in the relevant section.

Curriculum content

Of the students that were surveyed, 37% indicate that curriculum content of science is the main reason for their high points in school science experience. Students talk about learning new topics both early in secondary school as well as in Years 10 and 11; emphasising being engaged by interesting topics and learning topics in more detail.

[37] Not all students completed this section of the questionnaire (n=124) and some of those who did, put down more than one reason for their high points (n=131).

However, the most significant point made in the surveys is about science practicals being a highlight of secondary school experience (n=72). The following are a sample of comments from surveyed students:

> *It was fun doing practical experiments* SP16FNS
>
> *Year 7 was explosions and fun stuff.* R24 FSF
>
> *Lots of interesting experiments in Year 11* R68 FSP
>
> *Lots of practicals; science seemed fun*. C16 MNS

Many students completing the survey questionnaires list practicals as the high point of their school science experience by some naming favourite practicals in their high points:

> *I was excited to try out dissections* E20 MNS
>
> *Science was fun with experiments such as marshmallows in vacuum* R62 FSP

These survey findings are supported by interview data where students explain how practical work influences a positive experience of school science. For example, it can be seen from the following student's comment that getting involved in practicals makes science more interesting:

> *I think [experiments] were the only thing that made the lessons more interesting especially the ones where you have to mix the chemicals and they used to bubble; they were quite interesting. Year 7 we did quite a few with the Bunsen burner and everyone really enjoyed it because it was new. C14 FNC*

Although students have varied experience of doing practicals at secondary school with some enjoying practicals in Year 7 while others enjoyed them later in Year 10 and 11, the main theme emerging is that doing practicals is a positive experience and that science lessons are more interesting when there is an experiment or demonstration involved. The student above believes that experiments are the main reason that science is interesting and that science is more enjoyable because of the ability to carry out experiments that they were not able to do at primary school. Another student recalls how having varied practicals stimulated an interest in science:

For me the last two years, probably year 10 and 11 like I said it became more enjoyable and we had different practicals which we could get into. It wasn't the standard Bunsen burner or field trip it became more different and very varied ones that you could do and get different results. I remember this test we had to find out the length of wire that would be suitable for a toaster, so it gave you a challenge; it might have been silly but it was more interesting. C12 FSP

In chemistry you learnt about making perfumes, dyes and chemicals which were just a lot more interesting and the experiments were just a lot better.C15 FNE

The above student's preference for chemistry is influenced not only by the content of the subjects but also the experiments associated with the topics.

Turning to another aspect of the curriculum that influences a positive experience of school science is the idea of a challenge in a positive sense. This is illustrated by the following:

As science got more complex, it got more interesting SP4 FSF

We started learning more interesting and challenging topics B12 MSP

Science became more challenging and I began to appreciate it CL81 MSP

Other students write about curriculum content as a high point in school science experience in terms of interesting topics or ones that they had not encountered before:

I enjoyed the GCSE syllabus because it was broad and had interesting topics (R36 MSF)

New and interesting facts to learn (SP31 FNS)

In the interviews, students speak about different aspects of the science curriculum that increase their topical interest (Schiefele and Krapp 1996) in school science:

I actually took more of a liking to physics and chemistry through what was being taught and the content. C9 MSF

I think I always liked Biology because it seemed more relevant but some parts of Physics and Chemistry I enjoyed, stuff like the solar system, I was always interested in the solar systems and stuff and I enjoyed Chemistry because it kind of gave the basis to everything else. E4 MSF

These comments indicate that for these students, curriculum content has different ways of influencing their interest in science. For example, there is some evidence from the interview data that students doing more and varied practicals at school think science is more interesting. The idea that science is challenging and has new topics to learn also increases interest. This suggests that there is a link between interest and curriculum content; this is examined further in the section below.

The two main points in their school experience that students mention curriculum content as a high point are in Year 7 and Year 10. This is probably because Year 7 is the time that students encounter a new science curriculum as well as being introduced to science experiments in a school laboratory. The renewed interest in Year 10 reflects the introduction of the GCSE course at this point in secondary school.

Interest / enjoyment

Student responses explaining high points in storyline graphs use words such as enjoyment, fun, interest and a desire to learn. All these statements have been grouped together as interest/enjoyment because they describe positive emotions that may influence a desire to engage in and learn school science and also because they resonate with the claim made by Ainley and Ainley (2011; 69) that enjoyment and interest are closely related.

It is seen that there are different times during secondary school experience that students feel interested in school science. For example, some are interested early on during Years 7 and 8:

It was fun and interesting in the lower years C23 FNS

In year 7, science was new and exciting E15 FSF

It was fun and I joined the science club in Year 7 B17 MNS

Other students indicate that their interest arose later in secondary school once they started GCSEs; for example:

> *GCSE science was interesting* G15 MSP

> *I thoroughly enjoyed the lessons I had in Year 10 and 11 especially science of the body* E12 FNS

> *Very interesting content (in Year 11)* CL45 MSP

In the literature review, it has already been discussed how curriculum content encourages interest in students and comments such as these from the surveys support the notion that curriculum content is an important factor in encouraging interest and leading to positive experiences of school science. The literature review also provides a framework to understand the sources of interest in science; Trend (2005) highlights three types of interest – personal and situational and topical. These three types emerge clearly from the interview data. For example some students reveal a personal interest in science when they talk about being interested in science for some time:

> *I've liked science for pretty much as long as I can remember. R1 MSF*

Trend (*op cit*) defines topical interest as an interest in a small area of learning. Some students interviewed showed this type of interest in science. For example:

> *I have always enjoyed astronomy. That has been my key interest.* G3 MNE

> *I like biology because it is interesting learning about the body.* E3 MSP

However, a majority of students talking about interest mention a situational interest in science. Situational interest is defined by Hidi (1990) as an interest caused primarily by external factors. For example:

> *In Year 7…getting introduced to other new equipment and everything and I started to enjoy it. E8 MNS*

Other interview and survey comments show situational interest can arise from a number of factors apart from practical experiments such as teacher influence and getting good grades in science. These are explored in the relevant sections below. One of the important points about situational interest that was highlighted by Hidi and Renninger (2006) is that it may be transitory or provide the basis of a longer-lasting interest. This may have significance for the influence of the other factors discussed in this chapter.

Teachers / teaching

Teachers and teaching is as significant as interest and enjoyment in science for students that were surveyed with similar numbers of students indicating these as the reason for high points in their school experience of science. As discussed above, there is a relationship between teacher influence and interest in science and it will be explored further in this section.

The reason that teachers and teaching are discussed in this section together is because some survey comments make it difficult to disentangle teaching methods from teacher personality; for example, statements such as '*I had a good teacher'* or the comment '*my teacher brought science alive' (SP23 FSP),* makes it difficult to know whether it is the teacher's personality or the teaching method that provided a positive experience of school science for these students. Therefore, this section includes both factors although it is acknowledged that they are potentially quite distinct.

An insight into the way students perceive their teachers to be effective is seen when students talk about liking teachers for personality as well as teaching style. It is seen that both these characteristics can be inextricably linked in student comments as illustrated below through an anecdote taken from an interview transcript:

> *If you have Mr P[38] at first and you like him as a person, whatever he is teaching you are going to like it more no matter what.* C16 MSF

The student above emphasises how liking a teacher's personality can make a student like whatever subject they are teaching. This point is echoed in another students' comment that with an interesting teacher, science can become more interesting even when the work is quite dull such as coursework (see G12 MNC comment below). In the survey questionnaires, some students comment about how their teachers influence

[38] Students' own pseudonym for his teacher.

positive views of school science and contribute to the high points in their storyline graphs:

> *My physics teacher made it (science) fun exciting and interesting* E23 MSP

> *Teacher was always there, marked your work and made work fun/interesting* R62 FSP

> *Mr B*[39] *is a brilliant teacher and I learnt a lot from him* E42 MNS

These comments show that when students like their teacher or their teacher's teaching style, it has a positive influence on their experience of school science. These findings are mirrored in student interview comments such as:

> *During year 11 I had a really good teacher and that really made me enjoy it a lot.* C1 MNC

Other students interviewed also mention 'good' teachers and it is important to conceptualise what students mean by this to help explore how a good teacher influences positive perceptions of their subject. One way that students talk about good teachers is that they can make science interesting even when it might be monotonous or dull:

> *I had a really good teacher even the dull lessons weren't that dull. G12 MNC*

Looking at the particular characteristics of a teacher's personality that students like, it is seen that some students talk about their teacher being *fun* to emphasise the teacher's sense of humour:

> *The best memory I had of science I was in year 8 and we were learning about classification; my teacher she was pretending to be a lizard, she got down on the floor and started to pretend she was a lizard. She is my tutor now, she is so fun and yes, I think that was the best year of science. G1 FSF*

[39] A pseudonym

Another example is illustrated by the student below who talks about both teacher personality and pedagogical skills having a positive influence on her science experience:

> *I think he was the best teacher we ever had; he was really good. He had a way of teaching that was..... You always enjoyed his lessons and he was always really funny and he kind of messed around with you, if someone came in late he would say go on to the front and dance like a chicken, about the same time.... we learnt more in year 9 then any of the other years, we'd still learnt a lot from him but you couldn't notice how much you were learning because he was so much(fun)... the way he went about it, I really liked it in year 9; it was enjoyable, it was my favourite subject in year 9. G8 FNC*

Another student who articulates the influence of both teacher personality and teaching style on her school science experience is the example of this student who has spent her earlier years in a French science classroom and compares British and French science teachers:

> *In year 10 I really started to enjoy it (science) because I really understood everything and the way of teaching was really different. It's a lot more enthusiastic and they give you a lot more mental images and a lot more stories and they give you actions to learn; it might be more childlike but it is more interesting and subconsciously you learn what is being taught to you. Whereas in France you copy off the board and the experiments are done for you.C10 FNC*

For this student, a combination of teacher personality (enthusiasm) and teaching practice (mental images, stories and actions) have helped her to become interested in science and have a positive influence on her school science experience in Britain.

Another aspect of teachers' influence on science experience is the ability of the teacher to be a source of inspiration. Some students believe that good teachers are those that inspire their students to like the subject they teach:

> *Our Biology teacher and Chemistry teacher are amazing, they're really inspiring. R8 MSF*

When probed about his comment about a teacher being inspiring, this student explained inspiration as:

> *Passion about the subject…if you see that they're enjoying teaching the subject and enjoying teaching you, it encourages you to try a bit harder and make the effort to enjoy it as well.*

Similarly, other students talk about the teacher's enthusiasm and passion for the subject that makes the subject interesting for them:

> *I think that the way it was taught affected how I did it, because they (physics and maths) are quite hard subjects and you need an enthusiastic person to tell you it to be actually interested in it. C13 FSP*

For the next two students, having a teacher that makes lessons fun and enjoyable helped them to like science and contributed to the high points in their school science experiences:

> *In Year 7 …the teacher I got, I really enjoyed her teaching and that's what made me like science more. E8 MNS*

> *My Year 10 and 11 teachers…knew how to make the lesson fun, so it really came to life for me and I really enjoyed the lessons. C2 MSF*

Apart from the fun aspect, the student below explains how the teacher helped her to enjoy science:

> *She (Year 11 teacher) really made me enjoy science and made me learn really well as opposed to other teachers who I just didn't enjoy as much. With some teachers the style of their teaching was good and it made it stick in your head.C1 MNC*

This comment suggests that teachers who have a pedagogical style that students find 'good' helps students to learn science well which also contributes not only to interest in the subject but also learning it in a way that is related to feelings of success. Further evidence comes from the following students who say that the way teachers explained the basics made science interesting for them:

> *In year 9 and year 10 I had a teacher [who] made science really interesting and he explained stuff really well and if you didn't understand it he would really go through it really basic form and it was really interesting. G4 MNC*

> *I think the teacher at the time, the way he explained everything to me, I think he actually got me interested and that first interest is what pushed it from there R2 MSF*

An interview with a non-scientist who had a progressive trajectory highlights the importance of a good teacher. When asked about her high point in Year 11 she explained:

> *Because I had quite a good teacher in Year 11; it was a new teacher from Canada and I really liked him. I liked my lessons with him. That's when I started going to the after-school classes and that really helped me get a C (grade); I really didn't think I would get that. G17 FNC*

Also, the experience of a good or poor teacher is remembered by students a long time after the experience has occurred. For example this student talks about the influence of her primary school teacher:

> *My primary school teacher has always encouraged me because she was the one who set up my science club even though it was only a couple of days, she was the one who got me all the things and she got me my interest in science.* G11 FSF

Once this student started secondary school, she had variable experiences with her science teachers; some good and some bad. But, during the interview, it was her primary school teacher that she remembered most warmly and credited with her interest in science. The finding that most students still remember what their teachers were like from their early school years indicates the importance and lasting impression of teachers on school science experience.

To summarise, from the comments above it is seen that teachers and their teaching have a direct influence on students' experience of school science by making science fun and enjoyable. They also have an indirect influence on experience by encouraging an interest in science as well as helping students understand science and increasing student confidence and attainment.

Perception of science

In this section, perception of science takes on a broad definition including students' self-efficacy and their feelings that science is easy to understand as well as the confidence they feel when getting higher grades or moving to higher sets. In some respects, there is overlap with curriculum content particularly when students talk about science being easy; as well as with interest as seen above.

Perceptions of science as a positive experience receives considerably less student comment than the converse position – perceptions of science as a negative experience (discussed in section 5.3.1.2 below).

Most comments about perception of science as a high point are in reference to science being easy to understand or having less focus on exams. Students who make these comments in the surveys usually refer to their experience of science in Year 6 as well as the early years of secondary school. For example, the following students talks about her high point in Year 6;

> *Less focus on exams SP24 FNC*

The lack of student comment in the interviews about the influence of attainment on school experience of school science suggests that this aspect does not play a significant role on school science experience.

Attainment

Attainment has a narrow sense here in terms of examination results. Examples of their comments about attainment in relation to their positive experience of school science are given below:

> *In Year 11 I got good results in science and felt positive C96 FSP*

> *Started to become good at it (science) C125 FSP*

These statements show that students are encouraged by good grades and that these can contribute to a positive experience of school science.

The interview data helps reveal more detail about the attainment and its effect on school science experience. For example, in the interview, this student explains how being good at science was the reason for her high point:

> *My best year was Year 11; I was so into science for that year. I loved it; Physics was my strong point, and I was really good at science at that point. R7 FSF*

This student's comment suggests a relationship between interest and attainment; she was interested in the subject and she had good grades in it. Occasionally, some students indicate that success in science leads to an interest in the subject. For example, the following student's confidence is boosted when, once he started to work, he found science interesting and achieved good grades which motivated him further:

> *Throughout Year 7, 8 and 9, all I cared about was playing football so science wasn't on my mind. And during year 10 everyone was doing science so I just got into it and I found things quite fascinating, I was getting good grades and I liked it even more. C16 MSF*

From the comments above, it is seen that if a student is interested in a subject, it is easier to put in effort towards that subject compared to someone who is not interested; and increased effort leads to better attainment. This is further supported by the following response of a student to the question about whether having an interest in science made a difference to his attainment:

> *When you are trying to learn it and obviously you have an interest in it, it's going to help you learn it better, rather than being bored I find it interesting and actually do better. G5 MSF*

From these comments it can be seen that these students feel that having an interest in science enables them to achieve good grades in science. These findings resonate with Ainley and Ainley's (2011) findings that students who attain good grades in science are more likely to report their enjoyment of the subject.

5.3.1.2 Low points in school science experience

Turning now to the low points in students' experience of school science; the table below indicates the reasons for surveyed students' low points in their school science experience reported in order of the significance.

Table 5.5 the reasons for low points in the surveys.

Reasons for low points	No of survey responses n=506[40]
Lack of interest / enjoyment	140 (28%)
Teachers/ teaching	109 (22%)
Curriculum content	95 (19%)
Perception of science	86 (17%)
Classroom environment	42 (8%)
Attainment	22 (4%)

When compared with students' high points, it is seen that the overall categories for both are similar although the order of significance changes. The most significant of these changes is that of curriculum content which occupied a prominent position as a reason for students' high points but is not as prominent a reason for their low points. Also perceptions of science are more significant as reasons for low points. These will be discussed in the relevant sections below.

The first five aspects of low points in this table are discussed below comparing the comments made by surveyed students with those of interviewed students to look for converging, complementary and conflicting views. Only 4% students surveyed have indicated that attainment is the reason for their low points; therefore as discussed earlier (section 5.3.1.1) it is decided to disregard this aspect.

[40] This number reflects the total number of responses. Not all students (n=128) completed this section; while some (n=95) wrote more than one reason for their low points.

Lack of interest / enjoyment

A lack of interest in science is the most significant reason expressed by students in recounting their low points. Many students make comments such as

> *Science was boring.* R62 FSP

> *I didn't enjoy science.* B2 FNS

These comments seem to indicate lack of interest in school science but the difficulty with such general comments in a survey questionnaire is that it is impossible to probe the source. For example, it is not clear whether the student doesn't enjoy science *per se* or whether it is the influence of other factors that is the root cause of discontent. Rarely did students respond in detail about the relationship; however, a handful did attempt to add some depth to their responses:

> *I didn't enjoy the science topics in lower school.* C12 FSP

> *Year 7 science was not very practical or interesting.* R28 FSF

> *Boring and unrelated to real science.* CL18 MNC

Although it has been difficult to gain a deep understanding of why surveyed students didn't like or enjoy science, the students that were interviewed were able to add more depth to the reasons why they lacked interest in science:

> *I think, If I wanted to be a scientist, I would have done it anyway, because the teaching at this school is quite good but it's not something that interests me and it's not for me.* R3 MNC

Since it was easier to probe deeper into the reasons why students didn't like science in the interviews, I was able to identify different reasons such as influence of teachers or because of curriculum content:

> *I preferred Chemistry and Physics; but Biology I didn't really enjoy it. I was good at it, but I didn't really enjoy it, that could have been because of the teacher at the time.* R2 MSF

I just don't think it's (physics) just as exciting as (biology)...it's just I don't enjoy it as much. R8 MSF

I didn't enjoy science that much from Year 7 until Year 9. I think the curriculum was really boring and wasn't interesting at all. G10 FSP

From some student narratives, it is easy to see that there is some overlap between interest in science topics and their perception that there is also an element of difficulty that affects their interest:

Personally I don't think it's the most fascinating subject. There were some bits that were interesting, like Physics and stuff that relates to life is interesting but when it gets too technical I start to lose interest and when it starts to get too deep into the Physics concepts I start to lose interest. C4 MNE

Other students related their lack of interest not only to curriculum content and success but also to classroom environment. For example:

Come Year 8 we were put into sets based on results and I didn't do too good; I felt that the group wasn't as focused on science, they were messing around in groups and I felt I didn't enjoy it as much. E2 FNE

Although a large number of students in the surveys indicate that lack of interest is the main reason for their low points in experience of science; once, details are probed in the interviews, other factors emerge that have caused a lack of interest in science. This important point is discussed further in chapter 7.

Curriculum content

In the surveys, some students commented about being bored by school science topics which contributed to the reason for their low points in their experience of school science:

Boring topics that we were rushed through. C35 FSF

The content we had to learn gave me no motivation. R2 *FNS*

In addition to a boring and uninspiring curriculum, some students felt that science contains too much theory that has to be learnt for exams:

> *Too much theory and I felt I had to learn it all instead of understand it.* R15 MSP

> *We were just learning facts to pass an exam* SP23 FSP

> *Rigid curriculum left no room for any exploration of more interesting points. CL28 MNS*

From these comments it is not difficult to expand on what the students above mean by scince containing too much theory; they indicate that for them, science contained too many facts to be learned that left no room for interesting or creative aspects of science. There is also a perception that science facts need to be learnt to pass exams and that understanding them is optional. These points are congruent with comments from students in their interviews:

> *(From Year 8) they make you do more theory work – the teachers; and then it (storyline trajectory) just goes down.* C5 MNC

From the survey questionnaires, other reasons for low points in school science experience that have been categorised as curriculum content are repetition and an increasing workload that is too exam-focused:

> *The topics are interesting at a younger age but then it just gets repetitive*. C5 MNC

> *In Year 9 it's just repetitive stuff to pass the exams.* SP4 FSF

> *Too much theory, I felt it was about learning for exams.* CL53 MSF

> *GCSE science was repetitive and boring – too exam focused in comparison to previous years.* CL35 MNS

Interview data supports the survey findings regarding this negative aspect; for example:

> *[Explaining a decline in opinion of science] I think it was just work load, cause to*

start off with, when you're in year 6 and year 7, the younger years, there weren't any serious exams, whereas when those years came along, there was a huge work load on us and it sort of changed my opinion on it, it gave me negative outlook on science. R3 MNC

(My opinion of science fell) in Year 9 because we started SATS[41] *and it became a lot more serious; the sense where it was just a lot more academic than other years. R10 MNE*

Apart from repetition and excessive workload, for some students, particular topics are a source of boredom and dislike. During interviews, the students talk in more detail about specific parts of the school science curriculum and how it contributed to their low points in school experience:

In year 9 I didn't like science because I didn't think it was that interesting 'cause it was about food chains…when it goes to the ecosystem, that's the one I don't like. C6 FSF

In year 7, 8 and 9 we learnt more about rocks and stuff, which isn't interesting. G16 FNC

Physics with all the magnets and stuff is quite boring. R12 FNC

I really didn't like it (science) in Year 6 because we kind of went over and over plants and flowers and stuff; so I really hated Year 6. G8 FNC

In addition comments about the curriculum being boring or full of facts to learn, the majority of low points about curricular content are related to a lack of science practicals; with a number of students (n=35) surveyed indicating the lack of practical experiments at different stages of secondary school being the reason for the low points in their school science experience. This is illustrated by the following comments from the survey questionnaires:

There were no interesting experiments in those years. R31 MSP

[41] Standard Assessment Tests – science tests taken in Year 9.

Few practicals – too much theory. C25 FNS

*In year 10 and 11 I expected to do more interesting experiments but we didn't.*G25 MNS

There was not much practical work in the early years. SP18 FNS

This relationship between lack of science experiments and a decrease in interest is also evident in the following comments from students who were interviewed:

In lessons we just sat making notes, and the lessons [were] not that engaging and not enough activities. C7 FNC

…the best experiments we had in year 6 was seeing that a bottle weighed a certain amount which was kind of dull. G2 MNC

Although it is not surprising that these comments were made by students referring to low points in Year 6[42], primary school is not the only time that students experience a lack of practicals:

In 10 and 11 you get to do your own experiments whereas in year 7, 8 and 9 you usually do demonstrations and stuff so you kind of get less involved in the experiments. I think quite of the whole experiment side of stuff was really good learning about how chemicals react and stuff like that was quite fun. G13 MNC

And in year 7 we weren't trusted enough with the other experiments; we were told 'this is how you do it, this is what you will be doing' and then [after] it picks up a bit more. G2 MNC

In Year 10 we didn't do that many practicals and the ones we did were more of a demonstration and you was expected to answer questions rather than doing them yourself. E3 MSP

While most students give a lack of practicals as a reason for low points in the storyline graph, the student below is an example of a student who feels that the amount of

[42] Most primary schools do not have laboratories for science experiments or demonstrations. Scientific experiments are carried out in classrooms with very basic equipment.

practical work decreasing as he progressed through secondary school is the main reason for his increasingly negative perception of school science.

> *I enjoy biology practicals, but as you go from year 7 to year 11 it's such a big difference the amount of practicals you do; I think you do so much less in year 11 because in year 11 it's just getting the work done; they don't really relate it. Year 12 you obviously do it because it's A-levels but I think if you see from this graph from year 6 I have put down decreasing (trajectory) because that's what I feel.* C8 MSF

Sometimes school policy also has an effect on how students view the science curriculum:

> *It started off interesting at first year but then 'cause we have it every day because it's a science college and it's just too boring and too much work and I didn't enjoy it.R9 FNE*

In this case, the school is a Science Specialist school and science lessons are taught every day[43] . For students not interested in science, this can have a deleterious effect as they perceive that science has too much content that needs to be learnt in lessons every day and they gradually become demotivated.

The various aspects of curriculum content such as practicals and content of science topics described above have a relationship with interest in science. Some comments suggest that there is also an overlap of themes with difficulty in science such as students who talk about exam-focused content and too much work.

Teachers /teaching

In the section on influences of teachers on students' high points of school science experience above, it was seen that students seem to talk about teachers in terms of teaching method as well as personality; this is similar to the situation here. For example, students sometimes write down the names of teachers in their reasons for low points and it is impossible to determine whether it is dislike of the teacher *per se*

[43] This policy was a DfES requirement for progressively improved examination results in the subject specialism and some schools have chosen to keep this legacy.

or of their teaching method that is the source of negative experience. For this reason, when coding the survey comments, the negative influences of teachers and teaching are treated as one category.

22% of students responses from the survey refer to the teacher / teaching as the main reason for a less positive experience of school science. Comparing this to the students that were interviewed, the negative experience of school science in relation to teachers elicits substantial commentary from the students interviewed (43%).

In the surveys, there are many different ways students comment about their negative experiences with science teachers:

I had a really bad teacher who made me hate science. G34 FSP

Didn't enjoy science as the teacher was very discouraging. SP40 FNS

Didn't get on very well with the teacher. C55 MNS

These students seem to have a focus on personality aspects of science teachers while other students have a negative experience of school science because of the teaching method. For example:

Too much note-taking. dislike the dreary way it is taught, hate power points. E41 MNS

Other students that were surveyed talk about their negative experience of teachers in terms of teaching style or method. This is illustrated by:

Subjects were taught quickly and unenthusiastically (FNS R1)

From some of the above comments, it is clear is that if students dislike the teacher or the way a teacher teaches their subject, they will soon lose interest in that subject. Some students make this point quite explicitly:

Lost interest in biology due to the teacher and his teaching. CLS4 MNS

I hated physics because the teacher wasn't very good. C48 FNS

Comparing these survey findings with interview data helps to probe the relationship between teachers and teaching since it is possible to ask students what they feel about each aspect. For example, this student talks about how a teacher influenced his experience of physics:

> *In year 8 … having that one teacher (for physics) was really boring and I didn't really get on well with him at all and it kind of put me off it (physics) for life.* R4 MSF

There are two main points about the teacher's influence on this student's school experience that are significant here; firstly, the student feels that the teacher was *really boring* and that this deterred him from taking physics. The second point is that the student feels that *I didn't really get on well with him at all* indicating a poor teacher-student relationship that further contributes to his relinquishing physics not only for post-16 study but *for life.* The relationship between teacher personality and teaching method is also highlighted here as being impossible to say whether the student was bored with physics because of the teacher's teaching style, the content of the topics or because he didn't get on well with the teacher. After more probing, he goes on to explain how the teacher-student relationship has eroded in his case:

> *He kind of dismissed (everything I did) and wouldn't accept it and I lost interest in him half-way through the year…I thought having that sort of non-interest so early on when we just got split up into biology, chemistry and physics…it just ruined it for me*. R4 MSF

From the above statement it is seen that for this student, a poor teacher-pupil relationship has not only a short-term negative influence on school experience of science but a long-term negative influence on interest for the subject.

Interview data suggests that if a teacher is unable to empathise with students, both student and teacher are unable to form a relationship and this affects how the student perceives the teacher. For example:

> *I never really got on with my teacher, so that didn't help and then I didn't like the way it was taught and we never had a good teacher/ pupil relationship.*

That put me off. R5 MNC

I got a teacher [earlier in school] and she just put a downer on science for me. It was both her and the way she taught but I just think it was really boring. She never made anything fun or interesting. C14 FNC

These students both describe their teachers as someone they didn't get on with and they also explain that their teacher's way of teaching was boring and they didn't like it or were bored. The implication here is that the teacher has an influence on whether a student becomes interested in science or not; if students do not like the teacher, then they usually do not like the way the subject is taught and this will make them less interested in science. In other words, if you dislike the teacher you will dislike the subject as is illustrated in the following example:

I think the teachers I have had has a lot to do with it (decreasing interest in science) because I really don't like my teachers that much….when I had the two in the last year in year 10 and 11 for GCSEs, I really didn't enjoy it and I don't think they made the lessons very interesting and I think it actually made me dread going to science a little bit. C14 FNC

Some students talk about a lack of inspiration because of their teachers. For example, a science student who has taken Biology and Chemistry explains his reason for not taking Physics:

I think it's the teachers we have had in the past, they have just never inspired me to enjoy it, I can do physics…but I was just never inspired by it to take it further. R4 MSF

Similarly, another student says:

I actually have potential; it's just the fact that my lack of motivation of it really did depend on the teacher. G9 FNC

Both students above mention having the ability to cope with the subject but have not been inspired or interested enough by their teachers. The influence of a teacher judged to be boring or uninspiring is strong enough to discourage enjoyment of science; as this student poignantly says:

> *My teacher was dull to listen to and I forgot how interesting science was because she made it seem so boring. CLS20 MNS*

In another example of how teachers influence school science experience through a combination of teaching methods and personality, a student says:

> *It was the teacher I had at the time; it was her teaching style. I just didn't get on with the teacher, her teaching style, her personality and this particular teacher just completely ruined the subject for me. [Although] I found it really interesting but the trouble I got in to with this teacher just completely ruined it for me. It just destroyed my confidence in the subject. G18 MNC*

The turbulent teacher-student relationship *'the trouble I got into with this teacher'* has eroded not only the interest that the student had for science but also his confidence in science.

An important counter-point emerging from some student discourse is the idea that some students are able to look past problems associated with poor teaching and compensate it with studying independently:

> *I had poor teachers…they couldn't be bothered. I had to study myself. C16 MSF*

> *I think because even if I don't pay attention at school, I go revise at home using a revision guide I think I learn better. C6 MSF*

> *I know how to study myself – I don't mind the [poor] teachers now. G14 MSF*

These comments indicate that poor teaching does not always affect students in the same way. This important point is discussed in section 7.4.

Another aspect of teaching style that resonates with survey comments is a teacher's pedagogical style and how it influences students' views of the subject. Some students who were interviewed spoke about this aspect of teaching in the following ways:

> *She (the teacher) never made anything fun or interesting, she would make you*

sit there and make you listen when she was writing on the board. C14 FNC

Just the way they [teachers] go about it really, just flipping through PowerPoint presentations and talking at you, I think you won't enjoy that as much as someone who gets you involved. G8 FNC

All these students feel that such methods of teaching were not helpful ways in which they could learn. This issue is also raised when students discuss supply teachers[44]; although influence of supply teachers is one that has not been discussed widely in research on teacher influences on students, it is one that has had some influence on student experience of school science in this study. For example these comments from the survey questionnaire sum up the feelings of the students:

In year 8 we didn't have a teacher in science for like the whole year and we had supply teachers. E7 MSP

Too many temporary teachers ruined it (science) for me. G37 MSP

Didn't have a teacher for my science GCSEs C29 FNS

Too many supply teachers, hence lost my interest. R20 MNS

The teacher was off for half the year. E37 FNS

The comments above are from students in four of the seven schools where surveys took place and highlight the nature and scope of the effect of teacher absence and supply teachers. However, it was not possible to probe this issue further without the help of interviews. The interviews supported the findings above that students had a less positive experience of school science because of teacher absence and supply teachers teaching them science. Another theme emerging from the interviews is that students talk about supply teachers having an influence on their experience of school science in a different way to regular teachers. Above, whereas students talk about their regular teachers' teaching methods and personality having an influence on their experience of science; they talk about supply teachers' pedagogy and classroom

[44] Supply teachers are substitute teachers that take the place of regular teachers on long-term or short term absence.

management skills but not their personality. For example a student explained in her interview:

> *I think it was the teachers that changed so much it just made it quite hard to focus. In English I had the same teacher for pretty much the whole way through and because they know what they have taught you it's just a lot easier to go through things. G16 FNC*

High teacher turnover in some schools caused a sense of loss of continuity for the students leading to a less positive experience of school science. Some students felt that it was difficult to keep adjusting to the new teachers' pedagogical style. From the surveys, students indicate why low points in their school science experience arose because of temporary teachers:

> *Had temporary teachers and only worked from textbooks* B15 FNS

> *Teaching wasn't up to scratch as the teacher was off for half the year* E48 FNS

A complaint highlighted by students that were surveyed shows that some students lost interest in science because of the lack of science practicals in lessons taken by supply teachers, for example:

Had a supply (teacher). Only working from textbooks – not much experiments B59 FSF

These students' comments suggest that for them, science is interesting because of the experimental work involved. These comments also highlight that these students feel that the pedagogy of a supply teacher is different to that of a regular science teacher in that they do not carry out experimental work in science lessons[45]. This point was also made by some students who were interviewed as illustrated here:

> *…teacher went on maternity leave and we were given a cover teacher for the rest of the year and it just didn't seem right…the quality wasn't there and it*

[45] Supply teachers substituting for absent science teachers are not necessarily from a science background themselves. In most schools, the absent teacher sets cover work for the supply teacher for work to be covered in their absence. Since their lesson may not necessarily be covered by a science specialist and because of the planning involved in requisitioning practical equipment, cover lessons are usually set from textbooks or worksheets.

didn't seem right really. E3 MSP

My teacher got pregnant in Year 7 and we sort of had a supply teacher for the rest of the year. I had to do all the work myself because we didn't have a solid teacher. G17 FNC

Both the above students feel that a supply teacher is not the same as a regular teacher and that the quality of teaching is not the same.

Overall, from this section it is seen that teachers have an influence not just on interest in science but also students' confidence in the subject and on their sense of success as well. In other words, teachers affect the experience of school science *indirectly* through factors such as interest and success in science. This important point is discussed section 7.3.1.

Perceptions of science

From the survey comments and the interview findings, it is seen that there is a fine line between science being '*a challenge'* and being '*difficult'* with the former being a sometimes positive or sometimes negative experience and the latter always a negative experience. For example the following comments from the surveys illustrate how students perceive a lack of challenge as low points in their storyline graphs:

*Year 6 science was uninteresting and easy. No challenge (*R60 FSF)

The lessons did not go into interesting depth (SP2 FSF)

There is a nuanced change in some comments about school science being challenging:

GCSE science is challenging and difficult (C76 MNS)

*It (science) got really difficult in Year 10 (*B5 FNS)

Science was too hard (CLS92 MNS)

The shift here is from being challenging (more positive) to becoming difficult (more negative) and there are similarities between interview comments about difficulty of science with the survey comments. Students are able to explain in more depth why the difficulty of science caused a low point in their school science experience. For example, these students explain:

> *I just found it just so much information to remember (science) and so much information of how stuff worked and how the gases would condense. I couldn't really get me head around it; I don't like anything I don't understand.* C10 FNC

> *I think I found the biology side the most interesting and I never got on with the physics or chemistry side; I just couldn't get my head around the formulas.* G18 MNC

> *It's more confusing, especially when we started learning about atoms; everything you learn before is pretty much nonsense and it's just there to help you understand it, so it just makes it more confusing.*G11 FSF

One student explains why she didn't like chemistry:

> *I couldn't grasp it as much and when you can't grasp it, you don't enjoy it as much.* E2 FNE

There were many similar comments as the one above by students who were interviewed. A point to note was that comments about the difficulty of science were not just confined to any particular type of student; both types of students – scientists and non-scientists, made similar comments about how they struggled with particular science subjects. However, in the case of scientists, they persisted with the subject that they were having difficulty with while the non-scientists decided not to take up that science subject.

Classroom environment

The negative effects of disruptive classes on their school experience of science are narrated by students in both surveys and interviews. Since disruptive classes can be argued to be an aspect of the classroom not arising directly from teacher personality or teaching methods, it is discussed here as an aspect of classroom environment. However, this is not to say that some students didn't feel that their teacher was responsible for classroom environment as will be seen below.

The effect of disruptive classes on student experience is found in the comments of interviewed and surveyed students from three of the seven schools. Students mention peers who wouldn't let teachers concentrate on teaching and prevented other students learning. Some survey comments illustrate this below:

> *Although classes were streamed, there were still a lot at GCSE who caused disruption.* R59 MSP
>
> *Bad classes – hard to concentrate*. E68 FSP
>
> *In Year 7, students more willing to learn couldn't because of students not interested holding them back.*E58 FSF
>
> *Very poor lessons – was with a bunch of idiots* E6 FNS
>
> *Sets weren't well organised; disruptive pupils and teachers lost interest* E78 FNS

These students describe how misbehaviour in the class detracts from enjoyment of the lessons as the teacher is involved in trying to get the class to be quiet rather than concentrating on helping students who are quiet to learn or engage them with meaningful tasks.

Although the problem of disruption is limited to three schools surveyed, those students affected by disruption felt it is significant enough a reason for their low points in their school science experience (n=23). Some survey comments indicate that students blame their teachers' lack of classroom management:

> *Teaching wasn't good, and teacher couldn't control class.* E5 MNS
>
> *There were a lot of distracting students in the class so the teacher couldn't focus on teaching* E32 MNS
>
> *Teacher struggled to control class, so learnt nothing.* E17 MSP
>
> *Our teacher wasn't capable of controlling a class and didn't teach you anything* R62 FSP

During the interviews, a number of students (n=8) commented on their teachers' role in disruptive classrooms. For example:

> *The biology teacher couldn't control the class. ..so half the class time was spent shouting.* C10 FNC

> *I remember my physics teacher; he would just spend half of the lesson telling us to be quiet…he just split up writing bits of something and the majority of it being 'guys be quiet'.*C13 FNC

All these students feel that their teachers couldn't control the class and that this contributed to the lowest point of their school science experience. Some students like the ones above recognise that it is not poor teaching, but poor classroom control of teachers that has affected the way science is taught; nevertheless it still influences their interest in science. For example:

> *I did sort of have, well not really had a bad teacher but he wasn't as good. He couldn't control the class; it was very all over the place. I think it (science) is a very fixed subject and you have to really concentrate or otherwise you lose it completely. C12 FSP*

This student feels that disruptive students in her class affected the interest she had in science because for her, science is a hard subject that requires concentration and this is affected by disruptive episodes in the classroom. It is a note-worthy point that mainly female students report disruptive behaviour in the classroom a finding that echoes other research in classroom environments (e.g. Morris, 2012).

> *It was the behaviour of the other students, just completely ruined it for the rest of us. E9 FSP*

The disruption of lessons faced by this student caused her to lose concentration in her learning of science. Similar comments are made by other students who also experienced disruptive peers in their science classrooms and it is seen that this factor has a significant influence in discouraging students from an interest in school science.

To summarise the findings of this section (5.3) and to note its contribution to figure

7.2, school experience of science can be depicted in the figure below:

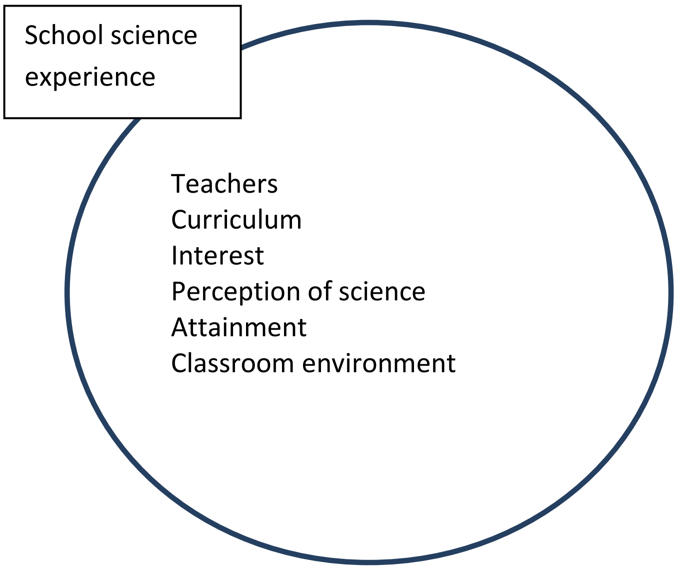


Figure 5.2 The high and low points of school experience of science

The high and low points on student storylines are assumed to be the significant influences in student experiences of science. These influences will be examined to understand the role they play in students' choices to take science or not after GCSE in chapter 7.

5.4 Student experience of the three sciences

In this study, although students are questioned about their experiences of science and their choice to take science as if it is one subject, it was acknowledged (see 1.3.1) that science is not a single subject and that student views of each of the three science subjects may be different.

Student experiences of the three sciences can be examined from the survey item about the three sciences (see Appendix D). 44% of students (n=251) answered yes to the question about whether the influence was the same for all three sciences compared to just 14% (n=79) who answered no to this question. A large number left it blank (n=239).

Of the 14% of students who did express a preference for the separate science subjects only 53 recorded their preferences (see fig 5.2 below).

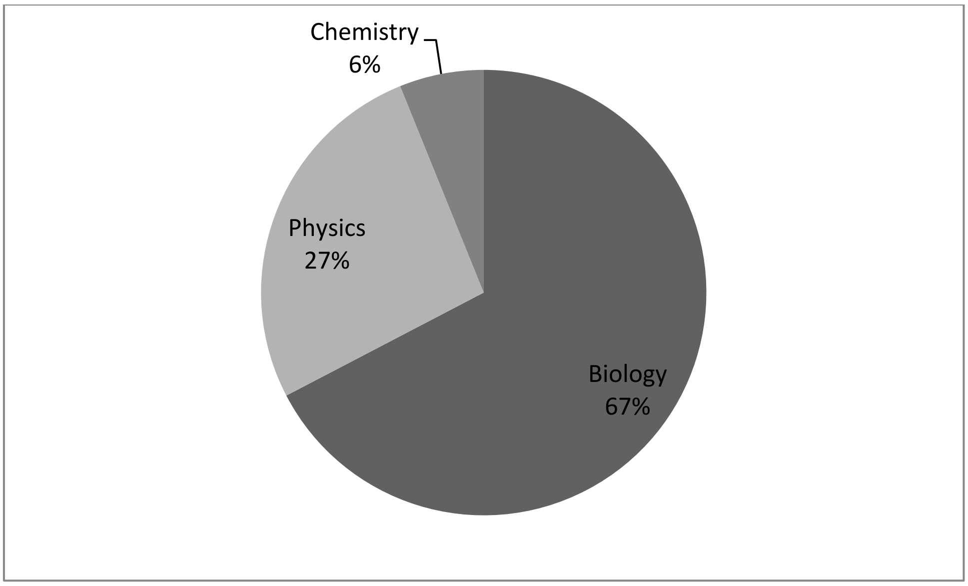


Figure 5.3 Subject preferences from student survey (n=53)

In the interviews, many more students spoke about their experiences of the three sciences (67%) because the interview schedule (see Appendix B) specifically asked this question. The answers helped understanding student views about the three science subjects. It became apparent during the interviews that a sizeable number of students (n= 13) were not aware that science consists of three separate subjects; these were all students from the non-scientists group. There was also the case of some students knowing that science consisted of three separate subjects but who were not sure which topics each subject consisted of. For example;

> *In Years 8 and 9 you knew there were separate sciences but sometimes you weren't sure which topic you were doing fitted into it so you knew there was biology, chemistry and physics but you're not sure which one you are doing at the time.E9 FSP*

A number of students (n= 10) did not have any preference for the separate science subjects:

> *I can't remember which ones are which but I enjoyed them all. E1 FNC*

> *I just don't like science, any science. G16 FNC*

> *I liked all three sciences. R8 MSF*

Of the students that spoke about liking or disliking particular science subjects in the interviews (n=38), the graph below indicates student preferences[46].

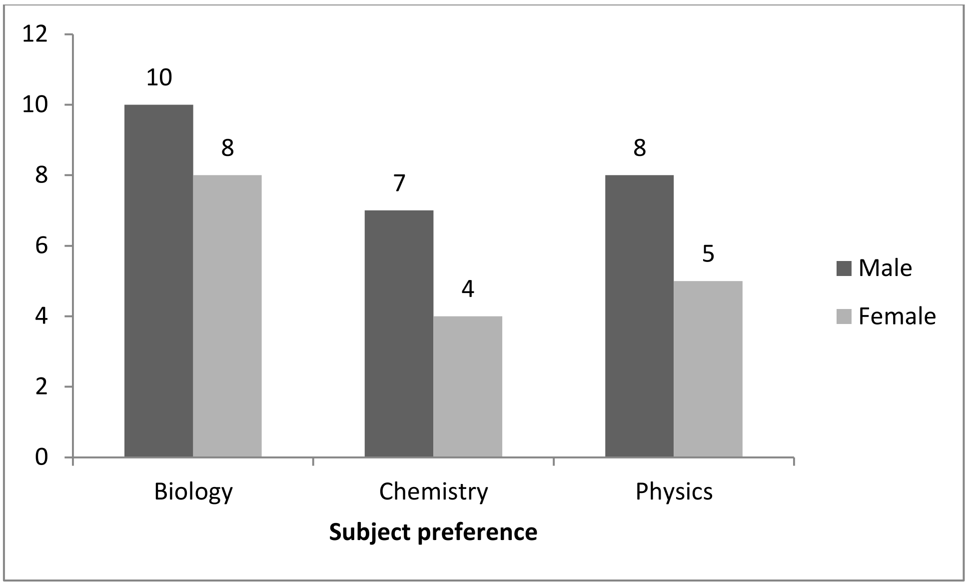


Figure 5.4 Subject preferences of interviewed students (n=38)

It is important to note here that this graph is based on student views of the three science subjects and as such, takes into account comments from both science and non-science students to present their views of school science.

The literature review highlighted that gender plays a role in preference for different science subjects and the table shows a similar pattern for each subject; biology is preferred by females in comparison to physics and chemistry. Testing for patterns between male and female preferences, a chi squared test of significance reveals that there is no significant difference between males' and females' preference for each subject. This is in contrast to studies such as Quinn and Lyons (2011) that find female and male interests are different in terms of science subject preference. However, the current study is based on a small sample that cannot be generalised or compared to the larger study carried out by Quinn and Lyons.

The graph also shows evidence that for this sample of students both females and males prefer biology to the other two science subjects. The finding that females prefer biology to the other two sciences is congruent with research literature findings;

[46] Some students indicated liking more than one science subject

however, the finding that more males prefer biology compared to the other two sciences conflicts with the literature findings (e.g. Schreiner and Sjoberg 2007).

Of the students that articulated a preference for one science subject over the others, the main reason was either because of perceived difficulty of the other science subjects or because it was one that they enjoyed. For example, this student articulates why she didn't like biology as a subject:

> *Biology, that's like body isn't it? I hated that. I liked more chemicals and stuff I guess. I just can't do bones and it was so much to remember; and I wasn't really interested in it either. G6 FNC*

Thus to conclude this section, there is evidence from the interviews that most students' preference for the three science subjects is different; however, survey results do not support this finding very strongly. There is a sizeable majority of students that do not know science consists of three distinct subjects and this may be the reason for the inconsistent survey results. This has implications for the way science is taught which is discussed in section 8.5.

5.5 Conclusion

The main aim of this chapter was to examine students' views of their school science experiences. The storyline trajectories emerging from the survey questionnaire can be grouped into one of four trajectories. In this study, the main assumption is that the trajectory of a students' experience reflects the school science experience of that individual – whether positive, negative or variable. Overall, the views of school science in individual years at secondary school for scientists show that there is an increasingly positive trajectory after Year 8 whereas for non-scientists, the trajectory remains the same just above neutral. Thus, science students have more positive experiences of school science at secondary school compared to non-scientists.

Analysing data on low and high points in school science experience, students' comments fall into six main categories – curriculum content, interest, teachers, attainment, classroom environment and perception of science. Frequency tables show that the most common reason for high points in school science experience for the students in this sample is curriculum content. Many students describe interesting topics and school experiments as being the reason for their high points. On the other hand, the most common reason for low points in school science experience is a lack of interest and enjoyment of science; students talk about being bored by science and not enjoying it. Although student emphasis on certain influences such as teachers and classroom environment is stronger in the interviews, the qualitative data from the survey data supports and complements the findings with little discord.

The findings of this chapter will be used in Chapter 7 to examine the role school science experience plays in decision to take science or not. The next chapter addresses the second research question:

> What are the reasons students give for deciding to study or not to study science post-16?

Chapter 6: Influences on students' decision to take science or not post-16

6.1 Introduction

In the previous chapter, students' views of school science experience are described along with factors that influence their views of school science. In this chapter, the factors that students describe as having an influence on their choice to take science or not post-16 are presented. The aim of this chapter is to address the second of the research questions:

> *What are the reasons students give for deciding to study or not to study science post-16?*

This chapter is divided into three main sections; the first section explores timing of science choice and when students choose to take science or not. This is done through quantitative analysis of survey data. The second section looks at the influences that students identify in their decision to take science or not from the survey questionnaire. This is done through quantitative and qualitative analysis of the survey questionnaires. The third section looks at the influences that students report in their decision to take science or not emerging from the interviews. The findings for this section are from qualitative analysis of the interview data. Finally, the summary integrates the findings from all three sections to present the argument to be taken forward to the next chapter.

In most sections, the findings discussed will be in terms of science and non-science students; but in sections dealing with interview data, the four categories of students discussed in 4.7.3 will be used to describe the emerging patterns in these four groups[47].

6.2 Timing of decision to take science

A number of studies claim that the ages of 11-14 are a crucial time in shaping student attitudes and subsequent behaviours in subject choice (e.g., Maltese and Tai 2010). One of the aims of the current study is to examine the relationship between the age of

[47] Since these four types emerge clearly from the interview data but not from the survey data

students and their decision to take science or not in a comparison to the findings of other research studies.

In the survey questionnaire, students are asked to indicate the time that they made a firm decision to take science or not in future. Figure 6.1 below shows that students in this study have mainly made decisions about taking science or not when in Year 11 (between 15 -16 years old). This is in contrast with other research studies that find students decide to take science earlier in school. For example, it is noted by Maltese & Tai (2010) that the decision to take science sometimes occurs before secondary school; however, the current results paint a very different picture. Very few students (5%) in this study made firm decisions about science earlier than secondary school; almost half of the students decided to take science when in Year 11. It is acknowledged that comparison of the current study with the Maltese and Tai study may not be valid since the current study is focussed on post-16 choices of students who have just embarked on post-16 study whereas the Maltese and Tai study involves scientists who have already committed to the science pathway and have achieved significant success in their fields. However, the evidence from this study is useful in that it shows that both scientists and non-scientists tend to make their science decisions at a similar range of times; between Years 9-12. The implications of this for careers advisory services and programmes in schools will be discussed in section 8.5.

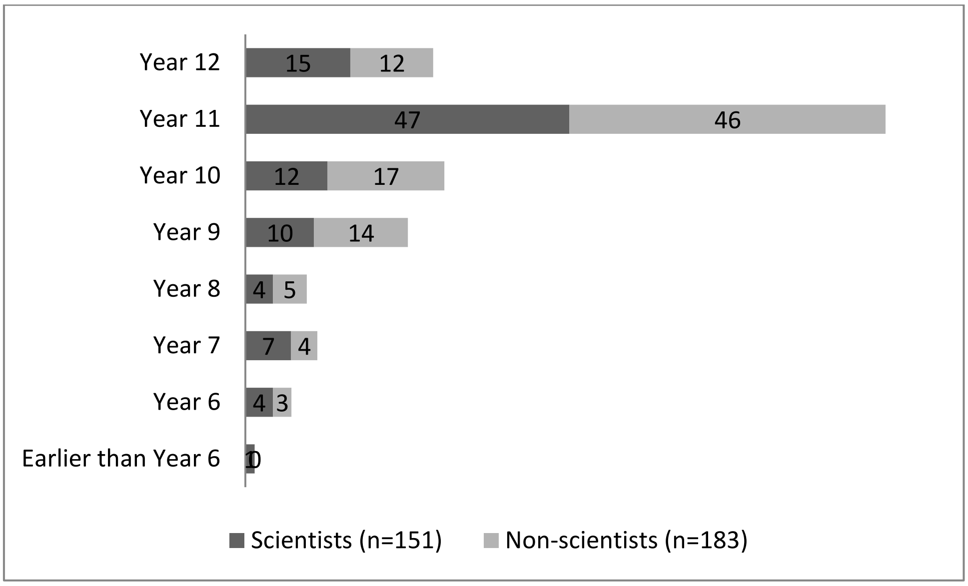


Figure 6.1: Percentage of students making a firm decision to take science or not at different times in secondary school

The students answered the questions about timing of their decision in different ways; the majority wrote the specific school year they made their decision, some wrote their age in years while others wrote ‘GCSE year’. It is this final group that presents a methodological problem and the way this has been dealt with is that ‘GCSE / GCSE year’ has been consistently counted as Year 11 rather than Year 10. Students when interviewed explained that they based their choice of science on their examination results and these are usually available once they have completed Year 11. Therefore, this is the reason I have chosen to quantify ‘GCSE year’ as Year 11.

Figure 6.1 shows that the majority of students (both scientists and non-scientists) make their decision to take science in Year 11. Looking at non-scientists, the pattern for not choosing science follows a similar track to the scientists; the majority of students decide they are not going to take science further when they reach their GCSE years. A noteworthy point is that a slightly higher percentage of students make the choice not to take science earlier in Year 9 in comparison to students who decide to take science. This may indicate that students are put off taking science early on school even before reaching KS4.

Focusing on scientists, as explained in 4.7.3 the interview data enables the group of scientists to be categorised further into future and potential scientists. To examine the choices of the two types of science student and the age at which they decide to take science, the cumulative frequency graph (6.2 below) of future and potential scientists shows that future scientists make a decision to take science earlier than potential scientists. Significantly more future scientists (53%) have decided to take science by Year 10 compared to the potential scientists (21%). Also, potential scientists decide as late as Year 12 whether to take science or not further representing a significant pool of scientists who make science decisions in the late secondary years.

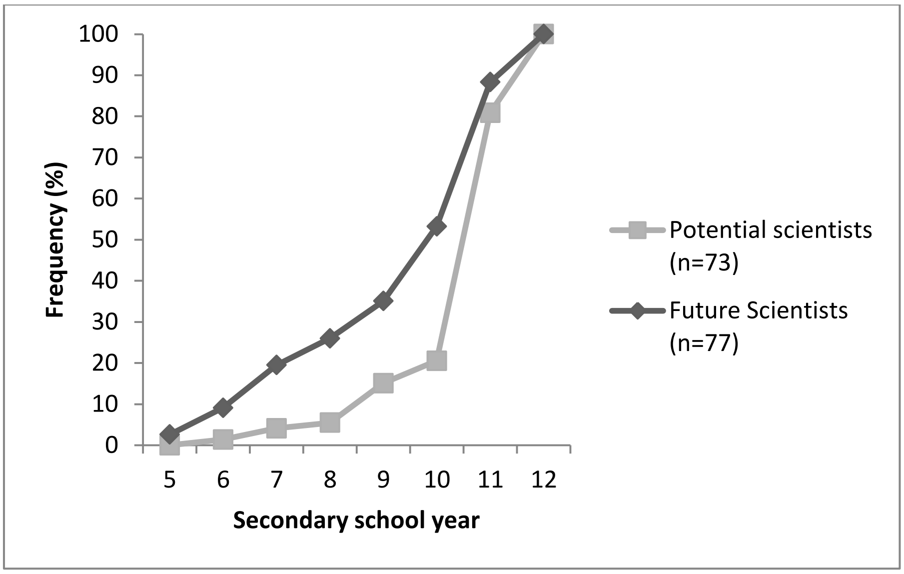


Figure 6.2: Cumulative frequency graph comparing the timing of decision to take science in future and potential scientists

GCSE results are the criteria for further science studies and enable students to know if they can take science at A-level; this may be the reason why there are a larger number of potential scientists that wait until their GCSE results to make a decision to take science or not post-16. This however, raises the question why a majority of future scientists are able to decide in Year 10 that they are going to take science post-16. A possible explanation for this may be in the structure of the GSCE examination system. Students are able to take GCSE science modular examinations in Year 10 and will be aware of the overall grade achieved. This suggests that future scientists are confident that they will gain the grades to be able to take science further while potential scientists may not have this confidence. This point is reconsidered in some of the student profiles in section 7.4.

In summary, the key point emerging is that most students in this study make their subject decisions later on in secondary school and there is a suggestion that exam results play a significant role in influencing a firm decision to take science or not further. This point is in contrast to research findings that indicate that taking science is a decision that is usually made earlier on in a students' life.

6.3 Key influences on students decisions to take science or not – survey findings

Before describing the survey findings about the factors that influenced the decision to take science or not, it is important to explain a methodological issue about the way the surveys were completed by students. This issue arose due to the absence of the researcher at the distribution stage of the survey questionnaires. It was intended that science students indicate factors in the column entitled 'these factors influenced me to take science' and that non-science students indicated factors in the column entitled 'these factors influenced me not to take science'. However in the total of 569 responses, a sizeable number of students (n=149) indicated factors in both columns. For analysis purposes in this section, responses about influences on not choosing science by science students are ignored; similarly, responses about influences on choosing science by non-science students are also ignored. Although it may be argued that there could be reasons for students indicating factors for not choosing science when they clearly have chosen science (and vice versa), while acknowledging this issue it has been decided to ignore those responses to keep the data free from ambivalence.

This section discusses findings from the survey question (Q4) in which students indicate how much influence six prescribed school factors have on their choice of science in the future. As such, although it is acknowledged that there are wider sources for students' decisions to take science as highlighted by the literature review, it is important to reiterate that the findings in this chapter are limited to school influences as much as possible. The survey questionnaire reflects the narrow scope of this study; for example, students are asked to indicate which of the six factors have had an influence on their choice of science or not. They were also given space to write down any other school influence that they think had a significant influence on their science choice. They were also instructed to put a ring around the single most influential factor.

By removing the ambivalent responses from the analysis, it is possible to separate the responses by the type of students – scientists (those who chose to take science after GCSE) and non-scientists (those who chose not to take science after GCSE). Student responses to the question about influences from the six school factors are set out in figures 6.3 and 6.4 below.

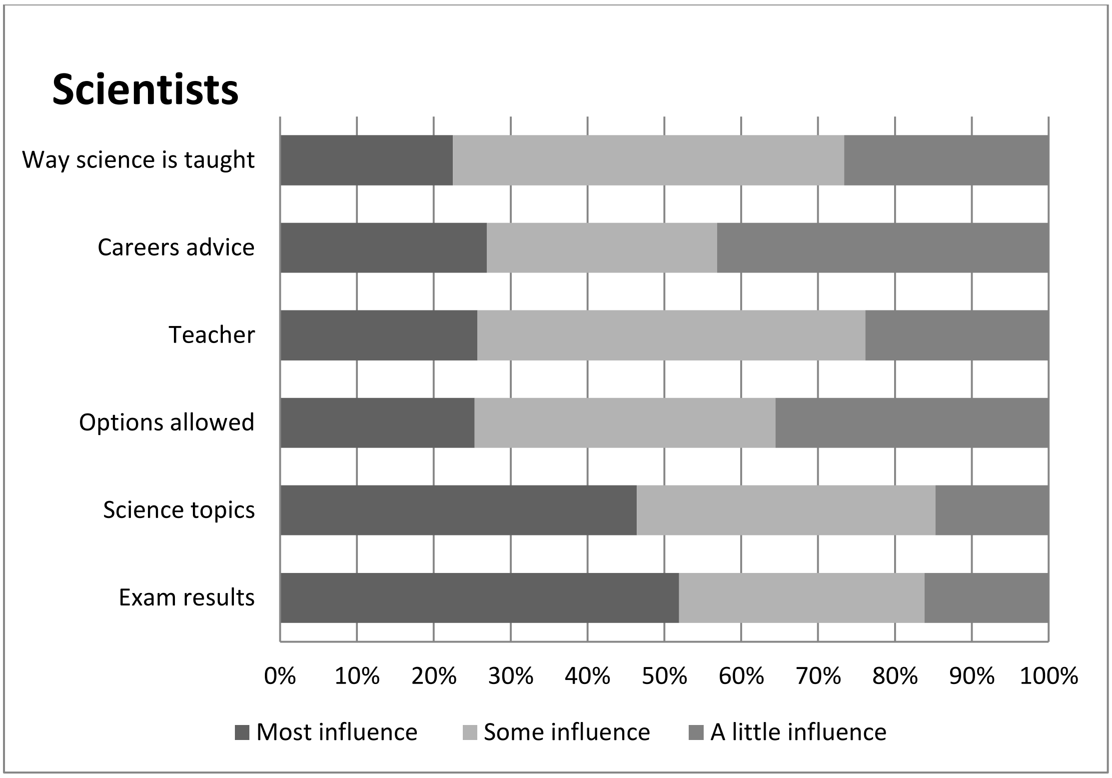


Figure 6.3 student ratings of factors that influenced them to take science (n=206)

The finding that exam results and science topics taught are the most influential in scientists' decisions to take science is not surprising since this is congruent with the other research studies (eg Lyons 2006). However, the finding that teacher influence is not as significant as science topics and exam results deserves some comment. In the previous chapter it is found that teachers have a significant influence on students' experience of school science and it was expected that there would be a similarly significant influence of teachers on decisions to take science; however, this is found not to be the case. A chi-squared test looking at the difference in ratings indicates that three factors – teacher, options allowed and way science is taught – are significantly different from science topics, exam results and careers advice (see appendix L). In other words, teacher influence ($p<0.01$), options allowed ($p<0.01$) and the way science is taught ($p<0.001$) have a significantly lower influence on scientists' decisions to take science. Thus, the number of students indicating that teachers influenced their decision to take science is significantly less than expected.

In contrast, the student ratings of factors that influenced them not to take science (the group of non-scientists) show a different pattern of significance of the different factors as seen in the figure below (6.4).

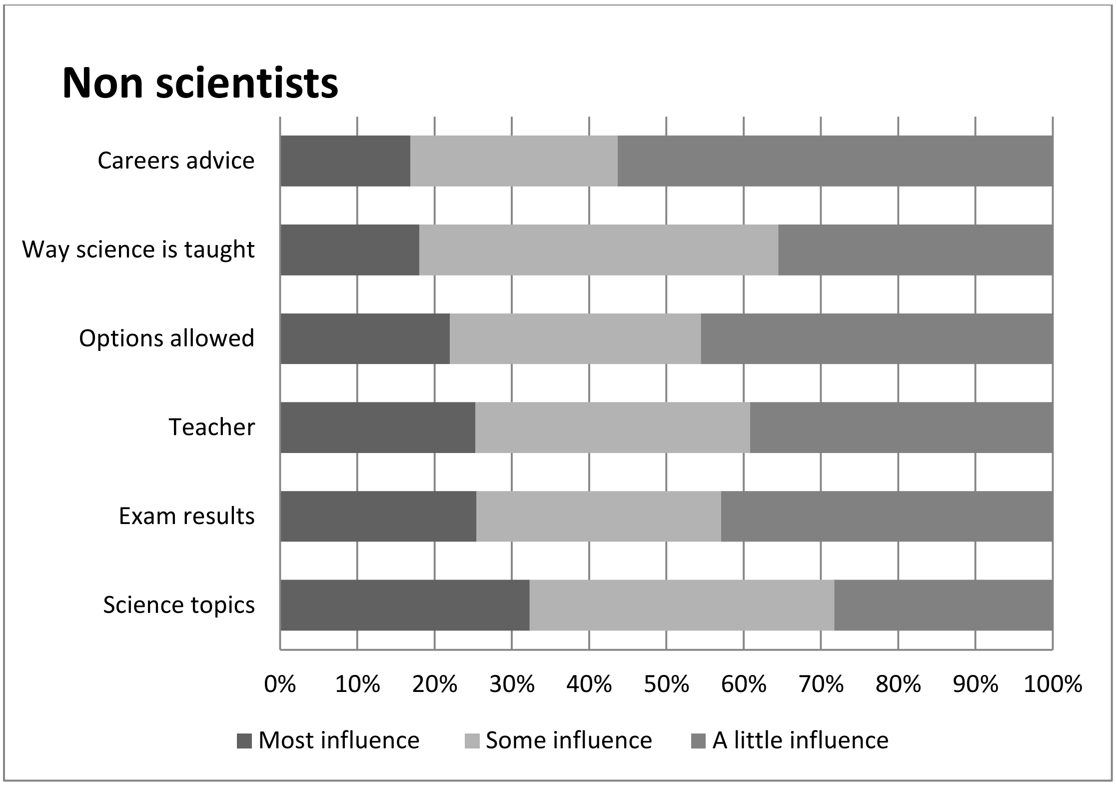


Figure 6.4 student ratings of factors that influenced them not to take science (n=248)

From this figure, student ratings for the six factors do not seem to show significant differences; however, a chi squared test (see Appendix M) indicates that significantly more students are influenced by science topics ($p<0.001$) and significantly less are influenced by careers advice ($p<0.001$) and the way science is taught ($p< 0.01$) into not taking science. The finding that students are significantly more influenced by science topics for not taking science after GCSE is not surprising since it was one of the more significant factors that students spoke about in their experiences of school science. However, it is perhaps somewhat encouraging to see that teachers do not significantly put students off taking up science after GCSE.

In an attempt to identify a single main influence on a student's choice to take science, students were asked to indicate the single most important school factor they felt to be the biggest influence in their choice to take science or not; these results are found in Table 6.1 below.

Table 6.1: Most significant influences on post-16 science take-up

Factor	Scientists (n=130)		Non-scientists (n=141)	
	#	%	#	%
Exam results	46	35	36	26
Science topics	29	22	45	32
Teacher	22	17	34	24
Careers advice	17	13	9	6
Way science is taught	11	8	15	11
Options allowed by school	5	4	8	6

The table above shows the number of students identifying factors as the most influential on their choice to take or not to take science. A large number of scientists identify exam results as the most influential on their choice to take science whereas non-scientists indicate that science topics taught in school are most influential in discouraging them from taking science.

Triangulating these findings with those from figures 6.3 and 6.4; for scientists, exam results and science topics are the most important influences on their decisions to take science while teachers, the way science is taught and options allowed by the school are significantly weaker influences. For non-scientists, science topics are significantly more influential in their choice not to take science in comparison to teachers and exam results. Careers advice and options allowed by the school are significantly weaker influences on their choice not to take science.

The findings above indicate that exam results and science topics are the two main influences in students' decisions to take science with teachers having a slightly lower influence. There is further evidence supporting this finding from multiple regression analysis (see below) of the association between the six items to student responses to 'Q4 What influenced you take science/not take science?' The association highlights that overall students' choice to take science or not is influenced by exam results ($p<0.001$) and the topics studied in science ($p<0.01$).

Table 6.2 Multiple regression of the association between the six factors and the decision to take science or not

Model	Standardized coefficients β	t value	sig
The teacher	.026	.549	.583
The way science is taught	-.38	-.781	.435
Science topics that were taught	.124	2.636	.009
The subject options allowed by the school	-.59	-1.222	.222
Careers advice given	.107	2.284	.023
Exam results in science	.257	5.497	.000

6.4 The key influences on students decisions to take science or not – interview findings

Through the general inductive approach to analysing interview data described in the methodology chapter (4.8.2.1), six themes emerge from the interview data (see fig 6.5 below). It is acknowledged here that there is a lot of similarity to the themes discussed in the preceding chapter (see also figure 5.2); it is reiterated here that those themes were based on student descriptions of the high and low points of their school experience while this section is about influences on decisions to take science or not.

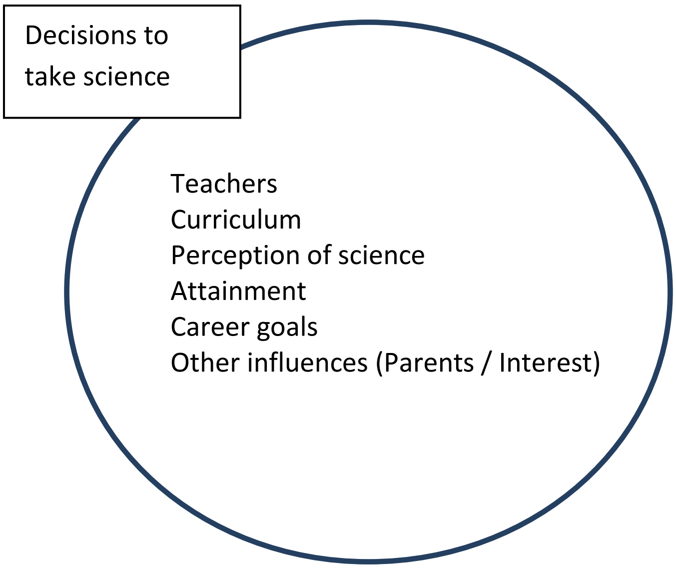


Figure 6.5 The influences on decisions to take science or not after GCSE

It is also important to highlight the difference in the influences in this section to the findings of the previous section (6.4). As explained in the methodology section (see 4.3 p53) and above in 6.3, the survey questionnaire consisted of six factors presented to the students *a priori* the results of which gives an insight into the influences on students' decisions. However, the influences emerging from the interviews (fig 6.5) are not the same as the factors in the questionnaire. However, when compared to the six factors from the survey data (see table 6.3 below), it seen that there is a lot of overlap. The two themes that are not mapped directly to survey factors are difficulty of science and school options allowed by the school. Difficulty of science is a theme that arose during the interviews but not the questionnaires because the survey questionnaire did not include this as a school factor; in contrast, the interviews allowed students to talk about any factors that influenced their decision to take science including influences such as difficulty of science. Options allowed by the school were a prescribed choice of school factors in the questionnaire which students did not mention during their interviews. Apart from these two, there is congruence between all the other themes from the interviews with the factors from the questionnaire.

Table 6.3 The themes emerging from interview data

Themes emerging from interview data	Factors from the survey data
1. Curriculum content	Science topics that were taught The way science is taught[48]
2. Perceptions of science	
3. Attainment	Examination results in science
4. Teacher influence	The teacher
5. Career goals	Careers advice given[49]
6. Other influences	
	The subject options allowed by the school

[48] The interviews revealed that students regarded this to mean experiments in science as well as learning formulae and learning 'facts'. As such, it may have some overlap with perceptions of science but in this study, it is taken to mean curriculum content since this refers to science experiments.

[49] Some students indicated in the interview that they had marked 'careers advice given' because they had career goals in mind that led them to choose to take up or not take up science post-16.

The six themes emerging from interview data are discussed below in order of frequency of student comments for each theme; this may help to clarify which influences have had the most impact on student decisions to take science.

It is also important to explain the reasoning behind designating parents and intrinsic interest as 'other influences'. As highlighted previously, the context for this study is school-based factors and both survey questions and interview questions have purposefully steered away from non-school factors. However, the semi structured interview questions make it possible for students to speak about other factors that have influenced their decisions to take science or not. Therefore, two relatively significant non-school influences to emerge are parental influences and intrinsic interest in science. Both are discussed below.

6.4.1 Attainment

In this section, attainment will be the term used for the narrower concept of examination results. From figure 6.1, it is seen that in the survey data, examination results is the most influential factor in student choice to take up science after GCSE. The interviews also suggest that examination results is a significant factor influencing decisions to take science; 78% science students in the interviews said they took science because of success in their GCSE science exams. For example:

> *The reason I chose science at A-level is that I got a decent grade in it; I was advised to do things that you enjoy doing and to choose things you would know you will do well in. E4 MSF*
>
> *I chose these subjects (science) because these were my strong points from GCSE. R2 MSF*

Further evidence for the importance of success in science is the finding that of the scientists interviewed (n=25), sixteen plan to take science at university; of the remaining nine students when asked what would make them take science at university, five articulate that success in the subject at A-level would influence that decision. For example:

I would only take physics at university if I was really good at it.G15 MSP

This comment about taking up science being dependent on success is also expressed by non-scientists (n=8); for example;

If I would have gotten a better grade, like an A or A in science, I would have taken up science instead.C4 MNE*

If you achieve a high grade at GCSE, you are more encouraged to take the subject further. SP7 FSP

Above, students have talked about the influence of success on their choice to take science; here it is useful to look at the reasons that students attribute to their success in science to develop an understanding of student views of the sources of success (or lack of it). It is noteworthy that many students spoke about factors that led to a lack of success rather than what made them successful. The main factors they spoke about are a lack of enjoyment and teachers having an influence on their lack of success. Looking at lack of enjoyment first, the following comments provide insight into the relationship between success and enjoyment of science. For example this student finds that without interest, he is not successful at the subject:

I just lost the motivation from having it (science) every day, so I didn't revise and just failed my exams. R9 FNE

It may be that an interest in the subject enables a student to be successful in it while occasionally the converse may occur; success in science leads to an interest in the subject. This interaction is an important point that is discussed in sections 7.3.1 and 7.3.2.

Because for example I take Biology and Chemistry and I don't really like Chemistry so I'm doing bad at it; but I enjoy Biology so I'm doing pretty good at it. If you like the subject you're more motivated to do it. C16.4 MSF

This student feels that he is less motivated to do chemistry because he doesn't like it; in other words, he relates the liking of a subject to being more disposed to working hard at it. In a similar comment, the following student explains:

I think you would find it more difficult if you don't slightly enjoy it you can lose interest and eventually you won't get the grades you need. C16.2 MSF

There is also evidence that students see difficulty of science related to interest as well as (lack of) success. For example;

I knew science was going to be harder at A-level. I started losing interest in it and did badly. C7 FNE

The following comments suggest that when students are interested in the content of a science subject, it keeps them motivated to carry on with the subject even when the topics are difficult. Consider the following two students:

Physics is hard but I wouldn't drop it, because I find it interesting and [the topics] we learn about interesting.G15 MSP

I dropped physics because the topics aren't that interesting. I have never really enjoyed physics that much. It's too much maths and after a little while it gets really boring and the practicals aren't that interesting and there's not much you can do with it. G11 FSF

Both these students agree that physics at A-level is difficult but for one student, interest in the topics keeps him motivated and he carries on with the subject despite it being hard. However, the second student doesn't find physics interesting and subsequently has dropped the subject because of its difficulty.

The other reason that some students attributed to their lack of success is teacher influence. Interview data shows that a minority of students attribute their lack of success to teacher influence. For example, some students interviewed feel that teachers have an influence on their lack of success in science and they speak about how they felt that having a better teacher would have enabled them to achieve better grades or more cryptically '*become better*' at science:

If I had a better teacher in year 9…I think I would have picked it (science) up better from there. C5 MNE

> *My sister had a very good teacher and she got an A. I think it would have done better if I had a better teacher. G17 FNC*

> *When I had a different teacher in year 10 she was quite strict but she wanted the best. At the end of the day she was the one who motivated me enough for me to get an A and I do think that if I stayed with her…basically if I had a teacher like her throughout my science study, there would have been a chance that I'd take science. G9 FNC*

The relationship between success in science and teachers is discussed further in the section below.

From the survey findings, exam results play an important role in scientists' decisions to take science; 35% indicate that exam results are the most significant influence on their choice to take science; corroborating the interview findings above. For non-scientists, the survey analysis reveals that exam results are a slightly less significant influence on science choice with 26% indicating that it influenced their choice not to take science. This is in contrast to the interview findings where 69% of students indicate that poor exam results influenced their decision not to take science. This may be due to the nature of the sample interviewed in contrast with those surveyed or simply because of the way data is collected by survey questionnaires and in interviews[50].

6.4.2 Teacher influence

Figures 6.1 and 6.2 both indicate that teachers are not such a significant influence on choice to take science compared to examination results and curriculum content. However evidence from the interviews suggests that teachers have an important influence where 71% of students that were interviewed talk about the influence that a teacher had on their choice to take science or not. The comments below are in response to interview questions about how teachers influenced the decision to take science or not. It is note-worthy that students talk about teacher influence on their decisions to take science mediated in terms of interest and enjoyment of science. This important point is picked up again at the end of this section.

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[50] Students are able to ponder their answers during the interview whereas the limited time allowed for survey questionnaires forces them to write down their answers quickly and move on to the next item.

6.4.2.1 Positive aspects of teacher influence

In the interviews (as well as in the survey) students often talk about their ‘good teachers’. The comments highlight that for these students, the concept ‘good’ involves both teacher personality and how they teach. Personality and teaching style are quite distinct characteristics but in student comments they often appear together as illustrated here:

> *In Year 9 and 10 I had a teacher who made science really interesting and he was really interesting…even though we were doing coursework in year 10 and we had him, it was just much more interesting. It didn’t seem as much tedious. G4 MNC*

This comment demonstrates how students conceptualise good teaching; by *making science interesting* through their teaching style and *being interesting* in terms of personality. The point made about tedious coursework implies that if you like a teacher, you will like whatever subject or topic that is taught by him/her. This finding reflects the findings of existing research on teacher influence on student interest (e.g., Logan and Skamp 2012).

Teacher personality

In discussing effective teacher personalities, the research literature very seldom describes the more ‘humanising’ accounts that these students give about their teachers. For example:

> *Everyone liked him; he was just really different because most teachers were strict but he was quite childish he liked Star Wars, and he liked quite good music. He was just really funny he would make fun of people and make jokes. He was really energetic and fun all the time…it made science more interesting and we did loads that year. G15 MSP*

Studies such as those reported by Logan and Skamp (2012) describe how students become interested in science with teachers they see as ‘fun’ and Wai Yung *et al* (2011) suggest that enthusiasm is a dimension students consider a characteristic of an effective teacher; however, the accounts in these two studies do not include fun as is seen in the above comments. This suggests that the definition of a good teacher is problematic; being a good teacher means different things to individual students. For example, the student above liked his teacher because *he liked quite good music* and *was just really funny.* Wai Yung *et al* suggest that being an inspirational teacher as well as having a sense of humour helps to increase students' interest in and enjoyment of science. This resonates with an aspect that emerges regularly in student comments in the current study about effective teachers and the ability of the teacher to be a source of inspiration. One of the ways that a teacher can inspire students is through their enthusiasm and passion of the subject as illustrated below:

> *I think that the way it was taught affected how I did it, because they (physics and maths) are quite hard subjects and you need an enthusiastic person to tell you it to be actually interested in it. So yeah I wouldn't have taken Physics and maths if I hadn't had my Year 11 teacher. C13 FSP*

> *I feel that the chemistry and physics teacher (were influential) because I feel that they both were really good teachers and they were really enthusiastic and that opened me up to doing physics and chemistry more because I felt if they have a enthusiasm for it then there must be something to be enthusiastic about. C9 MSF*

Inspiring teachers encourage an interest in the subject as this student explains:

> *Passion about the subject…I think, if you see that they're enjoying teaching the subject and enjoying teaching you, it encourages you to try a bit harder and make the effort to enjoy it as well. R8 MSF*

Teaching methods (pedagogy)

This section looks at students' views about their teachers' pedagogy. Borrowing from Watkins and Mortimore's (1999) definition of pedagogy as an activity designed by a teacher to enhance learning in a student; in the current study teaching style is defined as including a variety of components such as a teacher's style of teaching, the resources used by teachers and the way a teacher manages the classroom climate.

A student explains how the way a teacher teaches a topic is important in increasing their interest in science and as well as how a student subsequently performs in that subject at school:

> *I think that better teachers would have made the topic more interesting, and I think its how the teacher teaches the topic. I know that you have to work hard as well but I think the teacher makes all the difference and how you perform at school. C14 FNC*

For example this student emphasises the importance of the teacher affecting her performance at school and although she acknowledges that success is a result of an individual's hard work, she also emphasises that the way the teacher teaches the topic has an influence. Also teachers' explanations of science are an important facet of their teaching styles as is illustrated by the following students who say that the way teachers explained science made it interesting for them:

> *The physics teacher was very good but she was very crazy and she used to use all these actions and things to make us memorise things. She used to make us stand up and make us do the actions and things like that. C10 FNC*

> *When I got moved to a higher set, I got taught science a lot better and I got more interested in it. E2 FNE*

The influence of a good teacher on student interest in science is apparent even in students who have a personal interest in science and have planned to take science from an early age. This student explains how having a good teacher is important even though the student already has a passion for science:

> *I would have still been passionate about science but if they (the teachers) had made it boring then I would have had to be deterred, even though I have a deep passion for it, but if they made it boring I wouldn't do something I didn't enjoy, so yeah it would have really affected it (choice of science). C2 MSF*

The direct influence of teachers on decision to take science is alluded to in this student's comments:

I got a good teacher and that teacher kind of inspired me to take science, so I think teachers are important when you choose subjects and it affects a lot whether you're taking it or not. C16 MSF

My teacher is really helpful; I told him at the beginning of the year I wanted to do medicine. He pushes me and always asks how my work is going and he sets me goals. He's given me a lot of opportunities like currently I am working at SA (school for disabled) and he had a friend who was working there and got me in. C3 MSF

Another way that teachers can directly affect a student's decision to take science is by suggesting routes into science and encouraging students to take up science subjects. This is illustrated by the following comments:

I had a meeting with the teacher and she suggested I took up applied science for GCSE. G7 FSP

My biology teacher said I should take biology at A-level. G15 MNC

The comments here suggest that direct intervention by teachers also has an influence on students' decision to take science.

From the above sections, it is seen that the students believe that enthusiasm and teaching style are important characteristics of an effective teacher; this supports Wai Yung *et al* (2011) claims that good science teaching includes enthusiasm, teaching style and creating effective classroom climates. the evidence from the interviews provides an insight into how students feel teachers have influenced their interest and enjoyment of science and in some cases their decision to take science.

6.4.2.2 Negative aspects of teacher influence

Negative influence of teachers elicits substantial commentary from the students interviewed; more so than for positive aspects. There are a wide range of reasons why students feel teachers responsible for their diminished interest in science. As in the previous section, it is noted that students talk about both a teacher's personality and pedagogy influencing their decisions to take science or not. For example, students emphasise that it is both a lack of teacher-pupil relationship and the teacher's pedagogical skills that have discouraged them from taking science further:

> *I never really got on with my teacher, so that didn't help and then I didn't like the way it was taught and we never had a good teacher/ pupil relationship. That put me off. R5 MNC*

> *I got a teacher [earlier in school] and she just put a downer on science for me. It was both her and the way she taught; I just think it was really boring. She never made anything fun or interesting. C14 FNC*

Here, the teacher has an influence on whether a student becomes interested in science or not. The second student seems to imply that she found science boring and that this was compounded by the teacher who never made science interesting or fun. This leads to the point that students are influenced by an important part of a teacher' personality - being a 'fun' teacher. Student narratives about the influence of teachers who are not 'fun' help provide further evidence that being fun is a crucial characteristic in an effective teacher:

> *I wouldn't really have chosen [science] after year 11 because the teacher wasn't really that fun, I just thought 'I don't want to do that next year'. C14 FNC*

> *If the teachers aren't fun then I'm not going to enjoy it (science). C5 MNC*

In their comments, these students emphasise that to be 'fun' teachers need to be able to make their lessons interesting. When teachers are unable to make lessons interesting enough it leads to diminished student participation as this student illustrates when she explains why she truanted from her science lessons:

> *I think the teachers I have had has a lot to do with it (decreasing interest in science) because I really don't like my teachers that much….when I had the two in the last year in year 10 and 11 for GCSEs, I really didn't enjoy it and I don't think they made the lessons very interesting and I think it actually made me dread going to science a little bit. C14 FNC*

Other students talk about a lack of inspiration arising from their teachers as the reason for not taking physics:

> *I think it's the teachers we have had in the past, they have just never inspired me to enjoy it, I can do physics…but I was just never inspired by it to take it further. R4 MSF*

> *I was good at it (biology), but I didn't really enjoy it, that could have been because of the teacher at the time. R2 MSF*

Both of the students above mention having their ability in science subjects but not being inspired or interested enough to do so; they feel that it is their teachers who are responsible for the inspiration to take the subject.

Poor pedagogy

There is a suggestion from the literature review (e.g., Springate *et al* 2008) that poor teaching tends to put off students from taking science in the future. One aspect of poor teaching that a number of students comment on in their interviews is teaching style. Logan and Skamp's (2012) work on teacher effectiveness points out that students are not interested in extensive note-taking or excessive use of videos and ICT pedagogy (ibid, p22); similar points are highlighted by students in the current study:

> *I just didn't like the way we were being taught it… there was quite a lot of videos, which made it quite hard to write stuff down. G16 FNC*

> *My chemistry and biology classes were taught from the textbook which did not help me when learning. SP38 FNS*

> *Yeah he [the teacher] was the write on the board type person or copy out of the book…and I don't find it very helpful to learn. C13 FNC*

These students feel that such methods of teaching (copying from books or board) were not effective teaching approaches and feel that this contributed to their low grades in science. Another student explains how she felt about the way teaching style affected her interest in science:

> *Just the way we were taught; it went from all being kind of fun and having a really fun way about it and it was all of a sudden power points. We did do quite*

> *a lot of fun stuff but it was a lot less, which was kind of being like 'oh we got science' {excited voice} and all of a sudden it was 'oh we got science' {bored voice} and no one was really excited for science.G8 FNC*

This kind of comment articulates students' frustration with teaching methods used by their science teachers and helps illuminate the relationship between poor teaching and deciding not to take science.

Another aspect related to teacher influence that students comment upon substantially in their interviews is teachers' lack of classroom management[51]. Although this influence is mostly limited to three of seven schools in the study, a significant number of students (8/32) talk about the disruption caused by misbehaviour of other students. These students indicate the frustration felt when disruptive students hold others back from learning in the science classroom. One student explains that science is a hard subject that requires concentration and that this is affected by disruptive episodes in the classroom:

> *I think my teacher was good but he couldn't control the class, so it distracted you and you couldn't concentrate; you couldn't take in the full sense of or fullness of the lesson.C12 FSP*

The disruption of science lessons faced causes this student to lose concentration and led to a lack of enjoyment of science. Similar comments are made by other students who also faced disruptive peers in their science classrooms and it is seen that this factor has a significant influence in discouraging students from an interest in school science. Some students blame teachers for a lack of control while others indicate that teachers themselves lose interest in teaching science because of behaviour problems:

> *The teacher could be doing her best but just trying to control the class and the students just wanted to mess about, it did take away from the few actually wanted to learn*. E9 FSP

> *I remember my physics teacher; he would just spend half of the lesson telling us*

[51] The comments are similar to the survey comments in the preceding chapter about disruptive influences on experience of science in school but the above comments are in response to interview questions about influences on decision to take science.

> *to be quiet…he just split up writing bits of something and the majority of it being 'guys be quiet'.C13 FNC*

As the students above recount, misbehaviour in the class detracts from enjoyment of the lessons as the teacher is involved in trying to control classroom behaviour rather than concentrating on helping students learn or engage them with meaningful tasks. One student explains that:

> *I felt that the group wasn't as focused on science; they were messing around and I feel like I didn't enjoy it as much. E2 FNE*

The student above feels that disruptive students in her class affected the interest she had in science and it her interest increased only when she was moved to a higher set where students were more focussed on studying science. She also points out that teachers were able to teach a lot better when there were no disruptive elements in the class. Similarly:

> *In year 7 and 8 I was like I'm going to do medicine and as I progressed I thought actually I don't want to do it, because the teachers they're not bad teachers but they couldn't control the classes. With other teachers I could go and talk to them, but with my Biology I felt when I was going wrong I couldn't ask my teacher because she had her hands full and as I progressed I felt I was moving away from science.E10 FSP*

The student above feels that her Biology teacher had her *hands full* with the disruptive students in the class and this caused the student to think of the teacher as less approachable; not being able to ask the teacher for help when needed caused her to become discouraged in science. Other students narrate:

> *It was the behaviour of the other students, just completely ruined it for the rest of us. E9 FSP*

> *In Year 9 the teaching was abysmal. The teacher couldn't control the class and we never learnt anything. E7 MSP*

Similarly to E2 above, for student E7, being moved to a higher set enabled him to experience a better classroom environment, enough to make him interested in science. It is a note-worthy point that mainly female students report disruptive behaviour in the classroom. It may be because they are more affected by this phenomenon or it may be that the main perpetrators are male students; it has not been possible to discern which from either survey or interview data.

Teacher absence

The issue of teacher absence is one that is not discussed widely in research on teacher influences or on student interest and enjoyment of science; however, it is an issue that has significant influence on student interest in this study. The comments in this section are from students in four of the five schools where interviews took place and these problematise the nature and scope of the effect of supply teachers and frequent teacher turnover. For example, students experiencing high teacher turnover comment on the problems they faced:

> *When I was in year 7, 8 and 9, I didn't really have much (continuity). I had different teachers all the time so that kind of put me off science for a bit and then I lost focus and I wasn't interested in it. G6 MNC*

> *We had a lot of teacher changes because every teacher we seemed to have got pregnant. We all felt a bit lost. It was hard to keep adjusting to the different teaching styles. G8 FNC*

These comments suggest that students feel a lack of continuity in lessons; having different teachers means they have to get used to different teaching styles. Another problem that students highlight about substitute or supply teachers is the way the science lessons are taught. For example:

> *Had temporary teachers and only worked from textbooks E1 FNC*

This student links having a temporary teacher with an uninteresting lesson (copying work out of a textbook) and that this is the reason she felt a lack of interest in science. Another complaint that students experience with supply teachers is the lack of science practicals, for example:

> *No teachers, only supplies. No practicals until Year 11 and therefore no interest G17 FNS*

In the interviews, students were able to discuss in detail the effect that supply teachers had on their interest in science:

> *We didn't really have one teacher for the entire thing because we started off with one teacher and she had a baby, and then she left and we had substitutes for the rest of the year. And we really didn't do much for the entire thing because it was all substitutes and not many people really liked science. It was pretty dull because we never really did anything. G15 MSP*

This student's complaint that *'we never really did anything'* illustrates how students in science classes feel bored with the way that some temporary teachers teach science. Their comments suggest that these students believe temporary teachers do not teach science in an interesting way and that this decreases their interest in science.

The interview findings on negative aspects of teachers influence on interest in science complement and support the survey findings where 24% of non-science students indicate that teacher influence put them off taking science. The interview findings help understand how teachers put students off taking science as well as provide students' view of the characteristics of ineffective teachers as explained in the discussion chapter.

As highlighted in the section above about the relationship between success in science and the effect of teachers, the way a teacher teaches science has some influence on the way that a student learns science and subsequently the students' success in science; as this student comments:

> *The way science was taught put me off science; my chemistry and biology classes were taught from the textbook which did not help me when learning them. However, in Physics, a variety of techniques were used which really helped me to learn it. SP38 FNS*

This student emphasises that the way the teacher taught science from the textbook did not help her in learning either biology or chemistry; however, the way she was taught physics helped her not only to enjoy physics but helped her to learn it well. These related influences of success in science, teacher pedagogy and interest in science all contributed to the student's later decision to take up physics at A-level.

In conclusion to this section, it is suggested that the influence of a teacher for students is mediated through interest and enjoyment of science as well as through a sense of success. A note-worthy aspect picked up at the beginning of this section is that although the comments presented above have been in response to interview questions about the influence of teachers on decisions to take science, there is such an overlap with the previous chapter's findings of teacher influence on school science experience that this section could easily be mistaken for student comments about their school experiences. This suggests that teacher influence forms a part of a network of influences that are related to school experiences and to decisions to take science further or not. This possible relationship is examined further in the next chapter.

6.4.3 Curriculum content

In this section, experiments will be treated as a subsection of curriculum content as it is felt that there is an overlap between the two.

In the interviews the students (53%) talk about curriculum content influencing their decision to take science at A-level both positively or negatively. For example the following student has been positively influenced by curriculum content:

> *I thought I would have one main science which would be physics because it's the most interesting of any science subject because of what is taught; ideas and stuff.* G15 MSP

On the other hand, the following student has been discouraged to take up science further because of the negative influence of curriculum content:

> *Because of what we learnt in Year 10 and 11, I just didn't want to carry that on; it didn't interest me*… G6 FNC

Both these comments indicate that curriculum content has a bipolar role quality in students' decision to take science or not; where students' find that the content is interesting, they are influenced to take science further. On the other hand, curriculum content can also put off students and influence them to decide against taking science further. It is not clear from the second students' comments exactly what aspect of curriculum content moved this student to proclaim against taking science further; but it is assumed from her statement '*it didn't interest me'* that it was related to interest. These types of comment highlight the relationship between curriculum content and interest. The possible effects of curriculum content in science is probed in more detail below with the first section looking at negative influences of curriculum content and the second at the positive influences of curriculum content.

6.4.3.1 Negative influence of science curriculum

In the comments categorised as negative influences about interest in science, some students imply that the whole subject of science affected their interest. Their comments indicate a generally dismissive attitude to science; for example:

> *I found science boring…I started losing my interest in science like year 9. I had to take it for GCSEs and I thought it was more useful than interesting.C7 FNC*

This student's comments highlight a conflicting relationship between her lack of interest in science early on in secondary school and her views as science being useful a useful subject. Although she elaborated further that she thought science was useful subject to take for university and also indicated that she gained good grades in science, she explained that she did not take it further because the science GCSE topics were boring. Her narrative is one of several where students have highlighted gaining good grades in science but choosing not to take science further because they find the content boring and uninteresting.

Another variation of the overall dislike of science is seen in the narrative of students who talk about particular topics within science that they dislike. For example;

> *(In Years 7, 8 and 9), I didn't like science at all. I didn't like the sort of stuff that you learnt; I'm not that interested in science or anything about blood and all the stuff like that, it doesn't appeal to me. No I just don't like science, any*

science.G6 MNC

In the comment below, it is seen that even though liking a particular topic is sometimes not enough to compensate for the overall dislike of science. For example, this student explains:

> *In Biology I liked learning about blood and diseases but that was just a small part of the syllabus but when you get to plants and the kidney it's just so long (boring).C15 FNE*

Two interesting findings emerging from student comments and that have been raised by other research studies (e.g., Aschbacher *et al* 2010) are firstly the difference in male and female accounts about certain science subjects. For example, the male students' comment about not liking anything about blood *and stuff like that* in contrast to the female student who likes to learn about blood and disease shows a difference in view by gender.

Secondly, although Barmby *et al* (2007) find boys are more positive in their attitude to science, the interview data from the current study does not support this; a similar proportion of both males (n=5) and female (n=6) students seem to be negative towards the science curriculum. For example:

> *Chemistry was the least favourite of the lot because it just seemed very complex and very unnecessary, what you actually did in lesson…it was a bit strange. E3 MSP*

> *Well I have to drop one for next year and I think that might be biology just because I enjoy it the least; just because of the subject material. E9 FSP*

Apart from subject and topic aspect of curriculum content, there are other aspects of curriculum content that puts students off science is the type of learning students think they need for learning science:

> *I quite enjoyed biology learning about animals and the human body and about cells, but there were also parts which I don't enjoy at all, learning about ions and how to memorise the equations and everything, I didn't enjoy that, that's*

partially the reason why I stayed clear of science.R3 MNC

I didn't like remembering the formulas (in physics)…it was too mathematical. R6 MNC

These students emphasise that the need to memorise equations and symbols make them choose not to take science further. Other aspects of curriculum content affecting interest in science can be observed in comments about overloaded content and exam-focused science subjects. For example, in a comment reminiscent of Osborne and Collins (2001) about an overloaded science curriculum that is too exam-focused, the following student explains his decline in interest in science:

I think it was just work load, 'cause to start off with when you're in year 6 and year 7, the younger years, there weren't any serious exams, whereas when those years came along, there was a huge work load on us and it sort of changed my opinion on it, it gave me negative outlook on science. R3 MNC

Apart from comments about overloaded curriculum and exam focus, there are also several (n= 7) comments about repetition of topics taught in the science curriculum:

It just really got the same and it wasn't a subject that I enjoyed. It was a lot of the same work but just repeating itself, but in more depth.R9 FNE

The topics are interesting at a younger age but then it just gets repetitive. C5 MNC

These comments show how an exam-focused and repetitive curriculum reduces interest in science which also overlaps with students' views about science content being boring; discouraging them from taking science further.

6.4.3.2 Positive influence of science curriculum

In the interviews, fewer students speak about how the science curriculum increased their interest in school science and influenced their decision to take up science in comparison to the number of students who talked about the negative influences.

Of the few students who have spoken about the influence of the curriculum on their interest in science, most of them focus on topical interest (Trend 2005) in the science curriculum as being their main source of interest. For example, the following students talk about how their attraction to science was based in the nature of the subject matter:

> *…in year 11 I liked science because we started learning about babies and human bodies.C6 FSF*

> *In chemistry I was surprised because I thought I wouldn't enjoy it but it's been one of my favourite subjects this year…because of subject material. E9 FSP*

The enjoyment of subject content in chemistry has helped this student to develop an interest in chemistry and take it further to A-levels. Another aspect of the content that a student commented on is the progression of biology as he studied it through the years:

> *I like biology, it is challenging and its knowledge; building on things you have learnt before. E3 MSP*

In the comments about negative aspects of curriculum content above, some non-scientists mentioned the repetitive nature of the science curriculum; E3 MSP is a contrasting case where the student feels that biology builds on the knowledge that was learnt previously; his comment shows that not all comments about the curriculum being repetitive are negative. Another example is illustrated here:

> *…we learnt new things (in Year 7) and I suppose as you go through the school you just build on those things...C6 FSF*

This comment highlights the difference in views of students that choose to take science and those that don't; for some students science is repetitive and for others it is progressive. This suggests that there is a subtle difference in approach to science topics between the two types of students and one that may have a significant influence on the decision to take science further. This is discussed further in chapter 7.

6.4.3.3 Practical experiments in science

Experiments in science is an aspect of the curriculum that a large number of students (56%) talk about in terms of how these have either influenced their interest in science or caused a lack of enjoyment in science.

Students describe science experiments as 'practicals' and this word will be used synonymously with science experiments throughout this chapter. Practicals are broadly conceptualised by the literature (e.g., Cerini *et al* 2003) as activities that involve using apparatus and usually include demonstrations, class experiments, and circus of activities, simulations and role-plays; however, the majority of students interviewed in this study delimit practicals as classroom experiments that they do involving laboratory equipment. This narrower view of science practicals is the one that many students subscribe to as well as feel motivated by; they like practicals because it is a chance for them to be 'involved' or 'hands-on'. For example, this student claims:

> *I prefer getting involved rather than the academic, writing things down and the practical side really motivates me because I enjoy practicals. E5 MSP*

This quote above encapsulates how the students interviewed feel about science being an *active* subject because it usually takes place in a laboratory and this resonates with Donnelly's (1998) assertion that laboratories are physical places that 'demand' practical activity. From the interview findings, it is seen that students expect science lessons to include a practical element. A good example illustrating this is:

> *I liked doing experiments and the fact that we didn't just write in the lessons. G17 FNC*

It can also be seen from the following student comment that getting involved in practicals makes science more interesting:

> *In year 9 the teacher that took over from the other teacher who went on maternity leave, despite that he wasn't a very good teacher but he did bring a snake in to the lesson to demonstrate the biology of a snake and he brought in*

small things like that, so he used practical there and he involved us which was good. E3 MSP

This statement indicates the importance students attach to practicals; this student feels that the new teacher wasn't very good but is able to engage the students by doing practical demonstrations helping them increase interest in the subject.

The students interviewed have varied experience of practicals at secondary school with some enjoying practicals in Year 7 while others do more practicals later in Year 10 and 11. Overall, the main theme emerging is that doing practicals is a positive experience and science lessons are more interesting when there is an experiment involved. Out of 18 students who spoke about science practicals in their interviews, 7 students mention how science practicals increased their interest in science. Typical comments made are:

> *I enjoyed science because it was quite a lot of fun because we did practicals and all that kind of stuff.* E4 MSF

> *In Year 6 it was really positive because my science lessons weren't sitting around looking at textbooks, it was very hands on, we used to do really random experiments like running around with umbrellas and it was really fun.* C13 FSP

> *In year 7 and 8 I feel that when we did do the practicals it went pretty well and it was enjoyable and we had plenty of time with Bunsen burners and reactions, and not that we knew much about the content but it was fun and it was something that made me want to go to science lessons. C9 MSF*

The other 11 students talk about how lack of science practicals affected their interest in science. Typical comments they make are:

> *Year 9 (science) was boring because we stopped doing practicals.* E1 FNC

> *(From Year 8) I think they try and make you do more theory work so it isn't that fun.* C5 MNC

> *In year 9 and year 10, we didn't actually have that many practicals at this time*

and I didn't really enjoy (science). C9 MSF

The findings above resonate with Springate *et al* (2008) findings that students are encouraged to continue with subjects that have a significant practical element to the learning.

6.4.4 Perception of science

Interview data shows that science is perceived as a difficult subject that requires more effort than other subjects to achieve good grades. This is evidenced in student comments about their perceptions of real and anticipated difficulties in science. For example,

> *I have never really been good at numerical and science-based stuff; it's too hard. I have extremely slow hand writing and I struggle in exams. C5 MNC*

> *I found physics quite hard. I couldn't remember any of the stuff…that's what I disliked about the subject. E6 FNE*

> *When school science became more difficult it put me off. G2 MNC*

Some students have a notion that there is a gap between the knowledge acquired in GCSE science and the knowledge required for doing A-level sciences. This student explains:

> *I think I wouldn't be able to do it (science) this year, even though I got an A in it. I know but it's just such a big jump from GCSEs to A level I have realised when I think about it I don't think I would be able to do science. C14 FNC*

The above is an example of a student who has achieved good grades in GCSE science yet chose not to take it further because of the perceived difficulty. Another student talks about perceived difficulty of following a science degree in Palaeontology and has decided to pursue a non-science route:

> *I thought palaeontology would be a difficult course to pursue and probably a very complex one. C11 MNE*

In some cases of perceived difficulty, students comment that they hear about A-level science being more difficult from other people and that this puts them off taking science:

I have seen people who have done chemistry and physics and they're struggling as well because it's a huge jump from GCSE to A level and the amount of stuff you have to learn is (huge). E5 MSP

I thought that A-level (science) would be a lot harder… When we went to open days, they said that A Levels are a lot harder than GCSEs, so if you're not interested it will be a lot more difficult. C7 FNC

My cousins went to university doing science, doing biology; whenever I go see them and I see the amount of work they have to do for science that put me off. R6 MNC

Other comments suggest that students struggle to understand the material they have to learn for science. These comments are more commonly made about science in the latter years of secondary school. This student talks about science becoming more difficult as he progressed towards GCSE:

It (science) started to get intense…really hard and the amount of work I had to put in was kind of eating into my other subjects.R6 MNC

This comment suggests that the student feels that the work involved in science requires effort to the detriment of other subjects. Another student says:

I felt that I had to do so much in science to be able to keep up with what I want to do; it would be a big risk to do science. R7 FSF

These student comments about the risk of putting all her effort into science resonates with Eccles (2009) who claims that students calculate the cost of studying some subjects. This student implies that it is a risky strategy to spend so much time and effort on a subject to the detriment of other subjects. The notion of cost is also illustrated by the following student who thinks that the effort needed to succeed in science is not worth it:

Physics got too hard so I dropped it. The [physics] exams were just too difficult, so I decided it wasn't worth it. I just felt that I didn't understand it as well as I could have done. G11 FSF

Another way that students express their difficulty with science is to talk about ability in science:

With other people science just naturally clicks for them and for me it takes a lot of time. I would never consider it for uni because those people are really on top, and I don't think I'm that and the ones who do it at uni it just naturally clicks for them. C4 MNE

This narrative resonates with others who also believe in a 'natural' ability to be good at science; these comments are underpinned by the idea of self-efficacy in science. For the student below, work experience caused her to question her self-efficacy in becoming a veterinarian:

I wanted to go to college to do this veterinary sort of thing...but due to GCSE grades I thought I wouldn't be able to this. Well I did a work experience which was two weeks in year 10, and it was interesting but the sort of things you have to know. They were talking about this and that and it was like what are you going on about? I'm not going to remember this. I realise like...blown away what you have to learn; no I'm not going to remember that. E6 FNE

This lack of confidence in ability is often followed by a decision not to take up science any further. This is discussed in more detail in 7.3.2.

Sometimes, although a student may give up science when s/he encounters difficulty; not all students will give up as soon as they encounter difficulties. For example, the following student persists in science until he reaches 'the click' that he describes:

The [negative] way I felt about science never changed before because I only understood it a bit more later, it's only about year 11 my opinion about science changed. It's just a click, it's when you don't understand something and all of a sudden you think 'I don't know why I didn't understand this because this is quite *simple' but you just don't know why. I just got it and I enjoyed science after that.G14 MSF*

This scientist had negative perceptions of science and found it difficult because he couldn't understand it; but in Year 11 he felt that he finally understood science and the revelation that science is 'quite simple' helped increase his confidence and his enjoyment of science.

6.4.5 Career goals

Many research studies comment on the influence of career goals in science on the decision to take science further (e.g. Quinn and Lyons 2011, Vidal Rodeiro 2007). In the interviews, 38% students talk about how their career choices made them choose or not choose to take science at A-level. For example:

Just my passion and desire to becoming a dentist (made me take science); so I would like to do dentistry in uni if possible; just my mind set is to do that. C8 MSF

This student carries on explaining how his wish to do dentistry made him focus on taking science:

If I probably didn't have a goal, I think I would be more laid back in lessons and stuff and I probably wouldn't have done science because I wasn't sure as to what I was doing, I would have probably gone into maths or something else. C8 MSF

When students were asked about the factors that have influenced their career decisions in science, a large number of students (eight out of ten who chose science because of their career goal) talk about an early interest in a particular science career. For example:

It's a deep passion that I had since I was five and I was in an aeroplane and I thought to myself that I want to do something like build planes when I'm older and ever since that I've just had a deep passion to do anything with flying. C2 MSF

I always wanted to (be a doctor) even when I was little, I always played doctor and that; I didn't really have any other options.C6 FSF

Some students talk about choosing science because it opens up future pathways. For instance, a student doing the IB[52] had a choice between taking either an art and a science subject or two science subjects; even though he was musically inclined, he decided to take two sciences because he thought he *could go further if I had a more scientific education (R4 MSF).* This example illustrates how some students assign value to science in terms of it being a subject that will provide a scientific education to help in long-term plans and goals. Another student in a similar position explains how he came to choose to do Chemistry at university:

It (the revision class) just opened my eyes to that (Chemistry) as being a career; I just think I never considered it before and part of it was what you could go into with a degree in Chemistry. R8 MSF

This student shows that he has chosen to take a degree in Chemistry because it provides the opportunity to diversify into different careers. However, these are the only two examples in the sample of 32 students.

A significant point to note in the current study is the absence of any commentary by students about the role of their school in career guidance. These students have had their secondary schooling when a Connexions[53] service was provided by the local authority. In visits to the schools for interviewing, three schools had Connexions posters in prominent places[54] indicating that there is provision in at least these three schools. None of the students that were surveyed or interviewed mentioned any careers guidance they were given by school although there were a large number who spoke about parental influence on career choice.

6.4.5.1 Parental influence on career and subject choice

Although parental influence is classified as 'other influences' it is described here as

[52] International Baccalaureate

[53] A UK governmental agency providing advice, guidance and support to young people aged 13-19. Personal Advisers services are commissioned by local authorities to provide careers guidance in schools. This service is now in flux following a change in policy by the current Coalition government.

[54] E.g. main school noticeboard

part of career goals in acknowledgement of the importance of parents on career decisions by students.

Parental influence is an important influence in terms of students' career choice and consequently, subject choice. Many students in the interviews speak about parental support or lack thereof and it is apparent that this factor has a significant influence on student choice of science subjects. As argued in the literature review, parents provide their children with cultural capital by transmitting the attitudes and preferences and also in the way in which parents motivate their children. Thus parental encouragement can be argued to be an important part of cultural capital as emerges in the student comment illustrated below:

> *All my family's been into medicine and stuff like my dad and his brothers go into nursing. My dad always wanted me to go Into medicine and stuff... he'd always tell me stuff like how doctors save lives and stuff and I mean like he did come home and like he was a nurse and he'd come home and tell me stories like what he did and stuff. So I was like, that's really good...I want to do that when I get older. G1 FSF*

Here the parent wants his daughter to go into medicine and one way of doing this is to encourage her by portraying the value of a doctor as someone who saves lives. It is also seen that the parent motivates his daughter through his own attitude to nursing and telling her stories about his job because it is *good* and presenting it as something she should aspire to do when she becomes older. Another parent's encouragement is not so subtle but is described by this student as a 'push':

> *When I was younger my parents used to really push me you know for my feelings for science because my parents thought that was the most important three [sciences] so they really used to push me to work in them three so whatever I did it's 'cos of my parents because they pushed me a lot; they really did push me into them subjects E8 MNE*

Some parents wish to implement their own ideas about the career their child should follow. For example, from the literature review, it is seen that Bangladeshi and

Pakistani parental influence is a lot stronger than Chinese parents' influences and that they steer their children away from careers in pure sciences (Springate *et al* 2008). This point is illustrated by the following student's comments about his parents who are openly antagonistic to the student's choice of becoming a palaeontologist:

> *I'm from a very Asian background; I think they [my parents] tried to take me off it [palaeontology]. I decided to do medicine instead. C11 MNE*

The student explains how his parents believe that palaeontology is one of those courses where the pay isn't much and that would involve too much hard work. They suggested he take medicine like the rest of his family. Unfortunately, this change in direction wasn't successful and this student had failed his AS exams; coming back to school to retake the AS year with non-science subjects. Similarly another student says:

> *[My parents] think it's really hard to become a doctor, so they told me to change my line and do something with maths, I'm not really interested in maths I prefer science over maths. C6 FSF*

Sometimes it is not open encouragement or discouragement from particular careers or subjects that influence a student; Cleaves (2005) points out that passiveness erodes the value a student will have for a subject and this consequently has an effect on whether that student takes up a particular subject:

> *[My parents] have always said this and that is good but they haven't really pushed me to do one thing, they always said be good at it.R6 MNC*

> *My parents said you should do whatever you want to do; whichever one you think you will do well in. C4 MNE*

Sometimes, parents leave their child to decide what they want to do and it is difficult to know whether this is due to a lack of parental engagement or it is genuine difficulty in helping their children to make decisions. For example:

> *I think the final decision was me, no one really said to me that you shouldn't be an engineer. G5 MSF*

This student felt that he was responsible for the decision to become an engineer since his parents neither encouraged nor discouraged his choice. Some parents give support to their children even when they are not familiar with the choice their child has made. For example:

> *They have supported me all the way through really, they have said [forensic science] is a good thing to follow; they have supported me since way back when I said it. They haven't pushed anything on me, they don't have anything to do with science in their jobs, and it's all come from me. R1 MSF*

Similarly, another student comments:

> *It was mostly my decision but I obviously asked parents, what I should do, they were like it's up to you at the end of the day, I thought about it and I thought [taking science] was the best thing to do.* R2 MSF

These parents have given the role of decision-making to their son saying *'it's up to you at the end of the day';* however, this means that the student has to make the decision without the support of his parents.

Sometimes, parents can offer support for their child's decision in a subtle way without actually pushing them into a particular choice:

> *Well, my parents did actually have an input; I spoke a lot about it and I asked them what they thought about it like my options and they were quite happy about my choices; as long as I had two more sort of academic subjects [graphic design and psychology] that could possibly lead on to more stuff and it was something I enjoyed and they were quite happy to let me take that. G14 MNC*

> *[My parents] both work in an office all day. I don't think I would like that all day in the same office. I think that's why because I used to go to my mum's office when I was little I always thought I don't want to do this. G16 FNC*

> *I think they're just encouraging the things we would like to do, they're in jobs that it's not really what they want to do; they're encouraging us to do something we would enjoy. R3 MNC*

It is seen in the above cases that the parents want their child to do as well as possible in whichever choices they make. This may indicate that the parents want to appear engaged in the decision making process even though they may not be able to contribute by giving direct support for decisions. In the case of the first student above, his parents actively advise him to take ‘academic’ subjects that could lead to other careers.

It is argued in the literature that adolescence is a time when individuals will exercise their rights to make choices; and decisions about future careers can be seen as a lifestyle choice which students feel only they have a right to make (Marcia 1980 p161). This is apparent from comments where students speak about how they believe that career aspirations are solely their decisions to make:

> *It’s just my decision; it wouldn’t have mattered even if they [the parents] said we don’t want you doing that course I would have still wanted to take science.R4 MSF*

It is important to remember that these student reflections are their perceptions of their parents control over career choices; it is sometimes difficult for students to perceive or articulate just how much effect their parents have on their subject choices. They may perceive little parental influence on the subjects they choose, but it is seen from their comments that parents may have a very strong influence on career choice. This is illustrated in the comments of a student and his perception of his parents’ involvement in his choice of subjects:

> *Yeah, my parents obviously giving me all the support I need, they wanted me to study science as well but that’s not really an influence on me to be honest because they’re quite laid back and they said that you do what you think would be best, so obviously they gave me the push to do well, in maths and all the sciences rather than any of the other subjects. C8 MSF*

Here the student thinks that parents are *laid back* and allowed him to make his choice of science subjects; however, he also claims that they *gave him the push* to *do well* and acknowledges that this push is in science and maths rather than any other subjects. It could be assumed from this that although the student doesn't feel he has been *pushed* into doing science, he has had the support to ensure that he does well in science and maths and ultimately choose to take up science to become a dentist.

These comments suggest that parental influence has an important effect on career choice. There was no mention of peer influence on career choices which some studies (e.g., Sjaastad 2012) seem to imply.

The survey findings indicate that career goals are a much more important influence on scientists' decision to take science (27%) than compared to non-scientists (17%); this is supported by interview findings that career goals are an important influence in science decision-making for scientists.

6.4.6 Intrinsic interest

Intrinsic interest is a difficult concept to place in the analysis of this interview data; it is not really an influence arising from school factors but the large number of students who indicate interest as their broader response to questions about science take-up makes it hard to disregard its influence on overall interest and enjoyment of science. Intrinsic interest was not included as a factor in the survey questionnaire since it was not regarded as a school influence; but the interviews suggest that it has an influence on the way that students choose to take science or not in the future. In the sections above, there is much evidence for teacher and curriculum content influences being mediated through interest. It can therefore be regarded as one of the network of influences that lead to a decision to take science (see chapter 7). The interviews also provide evidence in revealing that some students are influenced by factors such as TV programmes, books and family trips to museums that encourage an intrinsic interest in science.

6.5 Summary

This chapter examined school-based influences that impact on student choice to take science or not by analysing both qualitative and quantitative data.

Quantitative findings from the survey questionnaire indicate that a majority of students believe school science has influenced their decision to take science. The survey data points to a focussed and narrow picture of student decisions that exam results are a dominant influence on scientists' decisions to take science and science topics are the most important influence on non-scientists choice not to take science.

The survey questionnaire presented six school-based factors that students could choose from to indicate the main influences on their choice to take science or not. These were useful in providing generalisable results. The interviews described a broader picture of the key influences that have led students to decide to take science or not post-16. In the final analysis it is preferable to use the emergent themes from the interviews since they more authentically reflect the student voice. These influences consist of six themes; teachers, career goals, curriculum content, perceptions of science, attainment and 'other influences'. The 'other influences' – parents and intrinsic interest – although not school-based influences are significant in the students' discourse and have been reported as part of the student voice. These six themes will undergo further examination in the next chapter where the third research question will be addressed:

> How does school science experience influence the decision to take science?

Chapter 7: The role of school science in student decisions to study or not study science

7.1 Introduction

In the previous chapters students' responses to the various instruments were discussed, and used to address research questions 1 and 2. They focused respectively on students' experiences of school science, and their perceptions of what had influenced their decision to take or not to take one or more sciences post-16. Overall the pattern is, predictably, one of complexity; students' decision-making does not follow any simple pattern, and is subject to a wide variety of influences both within school as well as with out. The present chapter seeks to explore the role of school science experiences to examine research question 3:

> *What is the role of school science in students' decisions to study or not study science?*

On the face of it one might begin addressing this question broadly by seeking simply to relate students' perceptions and rating of their school experience to their science take-up, using the large-scale questionnaire data. Section 7.2 sets out to do this from two perspectives. It first looks at the relationship between the trajectory of students' judgement on school science and their choice of A-level science. It also examines the relationship between their rating for individual years between Y6 and Y11 and their post-16 choice of science. Overall these data show some, but only a loose, relationship between these measures of school experience and choice of science.

Section 7.3 moves on to examine the processes underpinning these quantitative relationships. It draws on both questionnaire and interview data, including particularly the analysis offered in section 6.3 of the key influences identified by students. The particular concern here is to separate out the influences which can be wholly or partially related to school science and its outcomes, but because of the complexity of the processes it is not possible to focus purely on these. The account will be based around three broad factors derived from students' comments and an *a priori* judgement of what might be considered relevant in determining students' decision to take science or not. These three factors are Interest, Success and Utility value (Value from hereon) and are discussed in subsections 7.3.1 to 7.3.3.

Section 7.4 introduces a notion that will be called 'resilience' which emerges from findings in both chapters 5 & 6 as well as from section 7.3. This notion is explored in terms of the inter-relationships with the three categories mentioned above and the evidence that is employed to support the claims.

Finally, in section 7.5 how the various influences identified in section 7.3 play out in particular students is considered. This section will be organised into the four main categories of student trajectory that were identified in chapter 5 for each student type – scientists and non-scientist. The reason for employing this taxonomy is simply that it bears the closest resemblance to taxonomy of school experience. It also offers some further examples of the complexity of that experience by involving students whose experience do not fit any simple pattern.

7.2 The role of school science experience - quantitative findings

The main assumption is that the storyline represents students' experiences of school science; a progressive (P) trajectory suggests a positive experience, a regressive (R) trajectory represents a negative experience of school science while a progressive up and down (PUD) trajectory indicates a variable experience of school science. It is acknowledged that within each category there is some diversity (see appendix G and student profiles below for some examples). The survey data make it possible to examine quantitatively how school experience relates to take-up of science A-levels by comparing student trajectories with the number of A-levels taken. The following cross tabulation shows the number of science A-levels taken by students in each trajectory.

Table 7.1: the percentage of students in each trajectory taking science A-levels (n=567)

Trajectory	Number of science A-levels taken				
	0	1	2	3	Mean
P	77	52	51	19	1.06
PUD	56	29	23	9	0.87
S	45	17	9	3	0.59
R	118	31	21	7	0.53

The trajectories are P=progressive; PUD=progressive with ups and down; R=regressive; S=stable.

A noteworthy point is that not taking any science A-levels is the choice of the majority of students regardless of trajectory type[55]. But a pattern is discernible where more positive experiences correlate with a higher take-up of A-levels on average.

To find whether there is a statistically significant difference in the number of science A-levels taken depending on school experience of science (as shown by the trajectories), a single factor analysis of variation (ANOVA) was carried out (see figure below and Appendix O for details).

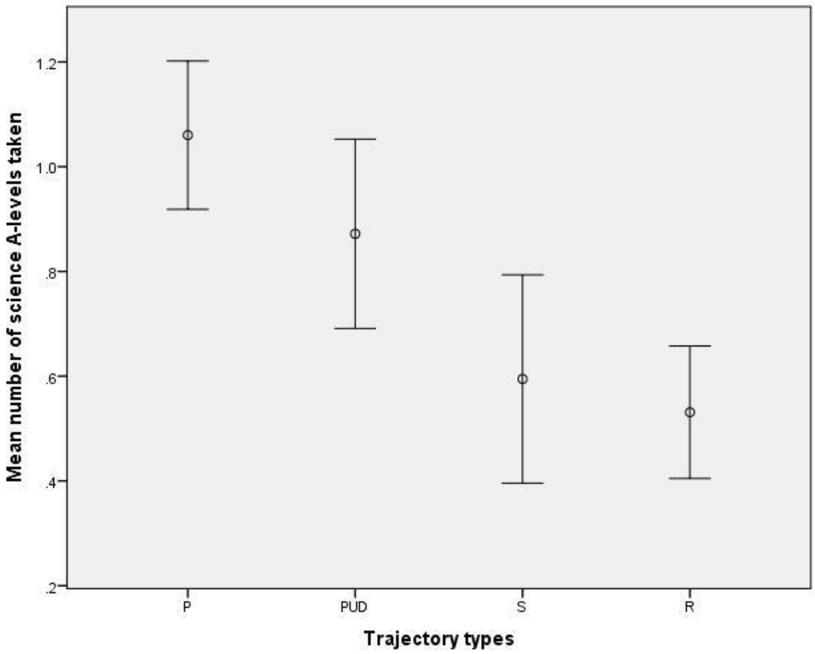

Figure 7.1 The mean number of science A-levels taken by students with each of the four trajectories[56]

The error bars for each trajectory type suggest that while there is no significant difference between PUD and S trajectories, there is a significant difference in the means of the number of science A-levels taken by students with P and R trajectories. More detailed analysis indicates that the effect is only modest; the effect size (r squared = 0.057) shows that 5.7% of the variability in science A-level take-up can be accounted for the by the different trajectories (see Appendix O for details of the analysis).

[55] For example, more students with positive trajectories take no science A-levels than those with positive trajectories who take at least one science A-level.

[56] Error bars showing 95% confidence intervals for the mean number of science A-levels for each trajectory (ANOVA test of difference in these means, p<0.001).

Knowing that 5.7% of the variance in take-up of science A-levels is accounted for by student school experiences, it can be explored how important each year is in the prediction of science take-up. To analyse this, a linear regression explored how students' annual ratings of science (Y6 to 11) predict the number of science A-levels taken (see table 7.2). It was found that Year 11 (β= 0.239, $p < .001$) was a significant predictor of the number of science A-levels taken. None of the other years (6-10) were significant predictors. The overall model fit was R^2 = 0.19 meaning it accounts for 19% of the variation in the number of science A-levels taken up.

Table 7.2 A linear regression model exploring how storyline responses in each individual year relate to take up of science A-levels.

	β	Std. Error	t	Sig.
(Constant)	-0.395	0.134	-2.951	0.003
Yr6	0.044	0.030	1.475	0.141
Yr7	-0.004	0.042	-0.097	0.923
Yr8	0.024	0.046	0.526	0.599
Yr9	0.057	0.041	1.379	0.168
Yr10	-0.040	0.039	-1.026	0.305
Yr11	0.239	0.031	7.756	0.000

This point deserves to be highlighted in terms of its support of the findings of Chapter 6 where many students attribute the decision to take science to their examination results (see figure 6.3). Year 11 is the time when students are examined for their GCSE and receive their results in the summer of that year.

7.2.1 The influence of school science on the decision to take science post-16

In the survey questionnaire, Q3 is '*did school science affect your decision to take science at A-level or not*?' The students answered either yes or no; those who answered in the negative were asked to explain which factor they thought had an influence on their choice to take science or not.

The table below shows student responses grouped by student type:

Table 7.3: Did school science have an influence on your choice to take science in the future?

Do you think school science influenced your decision to take science or not in the future?	Yes	No
Non-scientists (N=290)	171(59%)	119(41%)
Scientists (N=256)	201(79%)	55(22%)
Total	372 (68%)	174 (32%)

The data shows that a majority of students believe that school science has influenced their decision to take science beyond Year 11. A note-worthy point is that there seems to be more of a school influence on the decision for scientists than for non-scientists

Of the students who didn't feel school science had an influence on their choice to take science, the main reasons[57] given for choosing science were that it was their own interest (n=31) or they needed it for their career (n=40). For students choosing not to take science the main reasons stated were a lack of interest (n=41) or because it was not need for their future career (n=22). This suggests that interest and career are important influences on decisions to take science and is discussed in more detail in section 7.3 below.

7.3 Mechanisms through which school influences students' decisions

From survey and interview data about student experiences of school science (discussed in chapter 5) six themes emerged which described student experience. A similar number of themes emerged from student decisions to take science or not (discussed in chapter six). The six themes that describe student experience overlap to a great extent with the themes of student decision-making (see figure 7.2).

[57] Some students indicated more than one reason while some students left the question blank.

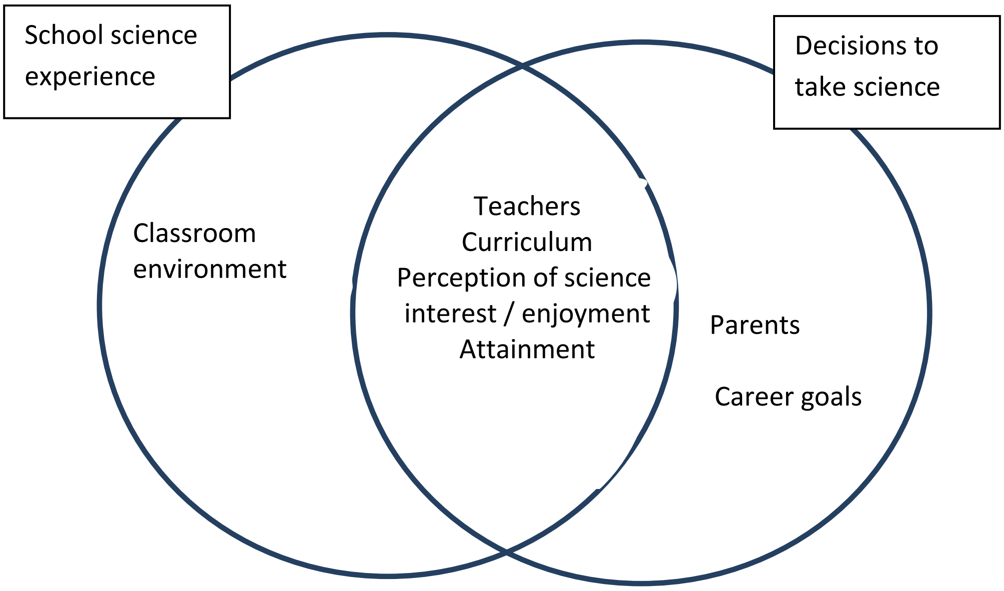

Figure 7.2 The overlap of themes from school experience of science and influences on students' decisions to take science

This overlap of themes indicates that school experience of science is a part of the mechanism of influences that lead to decisions of take-up of science or not in the future. My conceptualisation of how this mechanism works is explored in this section (7.3).

Firstly, I suggest that the themes from both school science experiences and decisions to take science can be loosely grouped around three factors – Interest, Success and (Utility) Value (see fig 7.3 below). These three key factors emerge from student discourse (see subsections 7.3.1 to 7.3.3 below for details and appendix P for an illustration) and from the literature review (see 2.3.6 for current understanding of interest development related to experience of school science and 2.3.8 for Eccles' EVT).

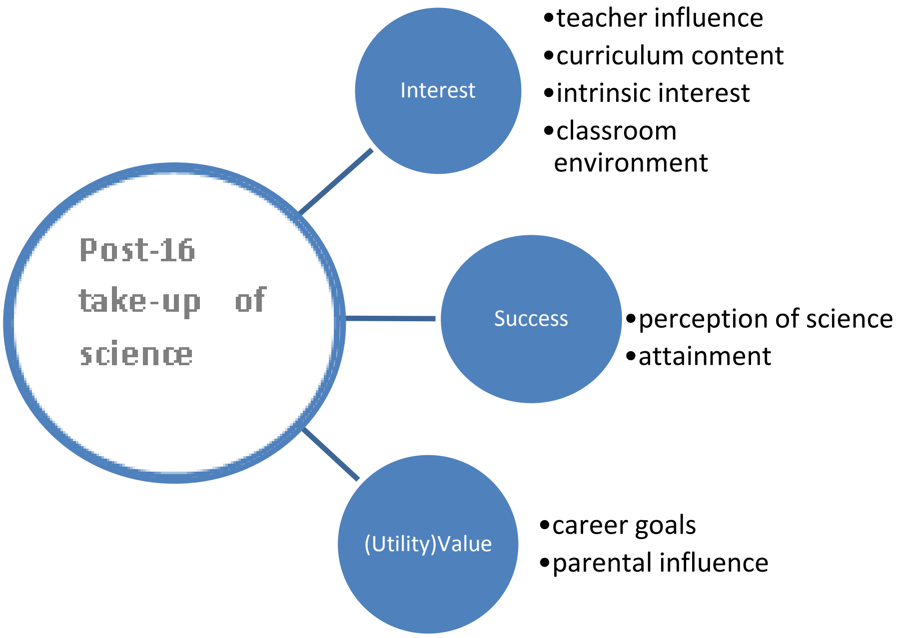

Figure 7.3 Conceptualisation of the three factors that drive student decisions to take up science

It needs to be stressed that neither the three key factors nor the themes are seen as being strictly fixed. School experience of science and decisions to take science are better construed as a network of influences (see figure 7.4 below) mediated by the three factors – Interest, Success and (Utility) Value (called ISV from hereon) in the decision-making process to take science or not. These factors might be seen as the key criteria which students employ when forming their judgements about taking science or not. The factors are critical to student decision-making and the themes relating to school experience influence the decision according to the extent that they play into each of these factors either directly or indirectly. Illustrations of how the factors and themes influence each other are seen in the student profiles in section 7.5 below.

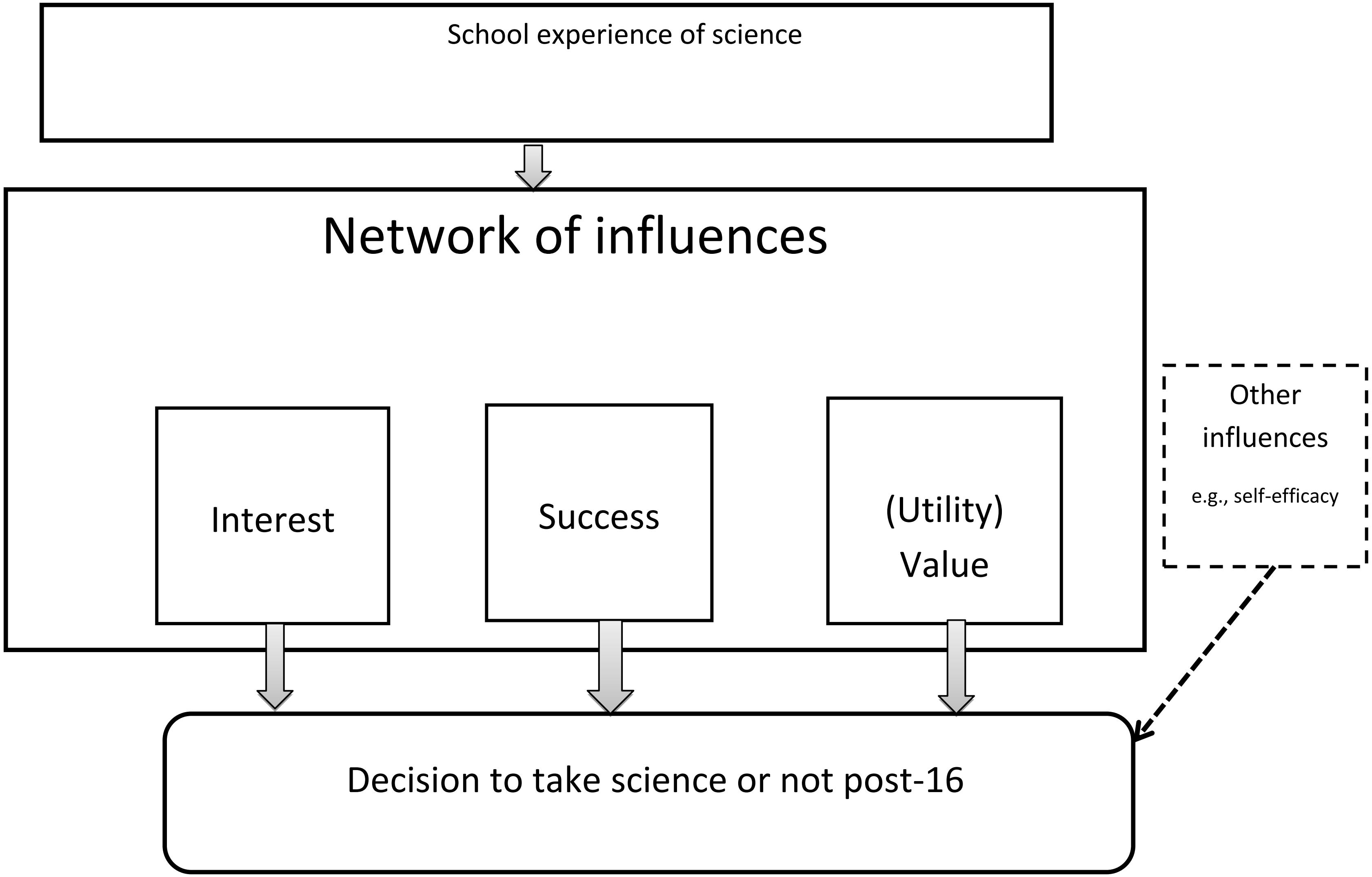

Figure 7.4 A model of the mechanisms on students' decisions to take science or not post-16

The claim within this section (7.3) is to suggest that the influences on decision to take science or not identified in chapter 6 and the themes of school experience identified in chapter 5 underpin and are mediated by the three factors ISV. It is also important to stress here that the three factors are not idiosyncratic influences on the decision to take science; student profiles (see 7.5 below) show that all three are related in nuanced ways. Although these student profiles are a small sample of the students interviewed, all the students interview transcripts were coded for ISV factors and mapped onto Venn diagrams for each of the four student types[58] (see appendix P). This helped inform the discussion in the following subsections where I will discuss the influence of ISV and where possible, show the relation to its underpinning elements in influencing a decision to take science or not[59].

7.3.1 Interest in science

Although it can be argued that interest and enjoyment are two distinguishable characteristics; interest as a person's predisposition to engage and persevere in a particular task (Renninger and Hidi, 2002) and enjoyment as a positive emotion in response to an immediate situation (Ainley and Ainley 2011), most students in this study talk about both interest and enjoyment synonymously when describing their experience of school science. This linking of enjoyment with interest is not uncommon and has been demonstrated in other research studies (e.g. Ainley and Ainley, 2011). Therefore in this study, both terms interest and enjoyment, will be described as Interest reflecting the way students talk about it.

Interview evidence shows that interest and enjoyment of science is an important factor that influences students to take up science or not after GCSE. 65% of the students interviewed have talked about how interest has influenced their choice to take science[60]. Of these students interviewed, 17 indicate that interest and enjoyment of science is the main reason they chose to take science at A-level while 8 students

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[58] Future scientists, potential scientist, non-scientist by choice and non-scientist by exclusion.

[59] On an editorial note, I have illustrated each of the following three sections with brief student quotes that appear italicised within the text; this stylistic deviation from the norm is intended to save space as well as to prevent impeding the argument.

[60] 36/55 students talked about interest in science – this includes students who talked about a lack of interest.

indicate a lack of interest in science that made them decide against taking science A-levels. It is not only school influences that have an effect on students' interest in science; there is also a non-school based influence - intrinsic interest in science – that is discussed below.

All the future scientists in this sample (n=15) claim to have an interest in science subjects; this is evidenced by comments such as *I find chemistry practically interesting, and that's why I want to go on and do it at university C9 MSF.* One student (C6 FSF) talks about liking science above English or mathematics while another (R2 MSF) explains that he liked chemistry but not biology which is why he took it at A-level. Similarly, eight potential scientists talk about being interested in science. The non-scientists by exclusion are just as interested in science as the future scientists with all eight students mentioning their interest in science (see appendix P); typical comments are similar to the future scientists such as *I was interested in science E2*. It is important to note here that an interest in science must be accompanied by success in science (see 7.3.2 below) for a student to be able to take science further as seen in the case of these eight students (the non-scientists by exclusion) who express an interest in science yet cannot choose to take science because they have been unable to gain the required grade to take up science A-levels. In the group of non-scientists by choice, there are also a few students (n=5) who talk about liking some parts of science or liking it earlier in secondary school.

There is evidence of the contrasting position – not being interested in science – that has influenced some students not to take science; mainly non-scientists by choice. Fifteen of these students talk about how they don't like science; *I didn't enjoy science C14 FNC* or they may show preference for other subjects; *I was interested in English G12 MNC.* Some of these non-scientists talk about boredom and lack of enjoyment to express their lack of interest. For example; *I never really enjoyed science…it's not something that interests me R3 MNC*. Also*, I found science boring…I started losing my interest in science like Year 9 C7 FNC*. Of the potential scientists, three of the ten in this group talk about dropping their science A-level because they no longer like the subject. It is important to note that not all influences underpinning interest in science stem from school influences. Although these subsections (7.3.1 to 7.3.3) will attempt to draw out the influences that are wholly related to school science - teachers, classroom climate and curriculum content including science experiments; there is also mention of influences partially related to school science such as intrinsic interest.

Looking at how **curriculum content** underpins interest in science, survey data (figure 6.1) shows that curriculum content is the second most important influence on decision to take science after examination results for the scientists (46%). For non-scientists, curriculum content is the most influential in their decision not to take science (32%). In the interviews, 41% of the science students talk about how curriculum content has influenced their decision to take science. There are two main aspects of curriculum content that are referred to; firstly, some students talk about the influence of curriculum in their decisions to take science in terms of their enjoyment of certain **science subjects and topics** within those subjects. For example, *I just like physics; it's the most interesting science for me because it applies to the real world G10 FSP.*

In contrast to this, curriculum content can lead to a reduced interest in science because of particular topics students don't like. This is also evidenced by the survey findings (see section 5.4) about the preference for the different types of science; more students seem to prefer biology (44%) than chemistry (18%) or physics (4%). For example, *there were parts which I don't enjoy at all, learning about ions and how to memorise the equations and everythingR3 MNC.*

The perception of science containing boring and repetitive course content is also a reason that students had a reduced interest in science subjects. For example, *it was a lot of the same work but just repeating itself in more depth R9 FNE.* Apart from boring and repetitive science curricula, students also talk about science content being rigid and exam-focused leaving them uninspired and disengaged. Students also talk about how the nature of science discourages them from taking science. From their comments it is seen that students perceive the nature of school science differently to the way curriculum writers intended. For example, *(science) is all about learning about ions and how to memorise equations and everything R3 MNC.* This perception of science being a subject that requires memorisation of facts coupled with the perception that there is a huge workload play a significant role in students' decision not to take science further and is discussed in detail further in the section about success in science.

The second aspect of curriculum content is highlighted by the large number of students who talk about **science experiments** and how they feel motivated to take science because of science experiments. Although science experiments are not directly influential in decisions to take science or not in future, student experience of science experiments (see 5.2.1) clearly have an impact on student interest and motivation in science (see 6.4.3.3) and it is this factor that influences the decision to pursue science.

There is of course an obverse to this; the high percentage of non-science students (68%) talking about the reasons that they chose not to take science after GCSE in the interviews indicate that the main aspect of curriculum content that decreased their interest in science is a lack of science experiments; in the interviews, more than half the students talk about how a lack of science experiments affected their interest in science. Typical comments are *in Year 9 and 10 we didn't actually have that many practicals and I didn't really enjoy it (science) C9 MSF.* The large numbers of students talking about science experiments is evidence of the extremely important role these play in increasing interest in science; this overlaps with the theme of teacher influence below, illustrating the difficulty of sharply distinguishing these various aspects of the network of influences within students' experience.

Looking now at how teachers underpin an interest in science, figure 6.3 shows that 26% of science students responding to the survey questionnaire think **teachers** positively influenced their decision to take science. From comments such as *in Year 9 and 10 I had a teacher who made science really interesting and he was really interesting G3 MNC* , it is suggested that teachers influence interest in science both through personality as well as pedagogy. **Teaching methods** are an important influence for some students exemplified by this student who explains how her teacher made science interesting; *the physics teacher was very good…she used to use all these actions and things to make us memorise things C10 FNC.* Another student says *the way of teaching is a lot more enthusiastic and they give you a lot more mental images and a lot more stories and they give you actions to learn C10 FNC.* Other students talk about their **teachers' enthusiasm** in teaching science; for example, *they both were really good teachers and they were really enthusiastic and that opened me up to doing physics and chemistry C9 MSF*. However, there is a discrepancy when the number of students talking about positive effects of teachers on their interest in science decreased to 6% of students in the interviews[61]. In comparison to this, a larger number of students interviewed (22%) felt teachers have had a negative influence on their interest in science. Students talked about a wide range of reasons why they felt teachers are responsible for their lack of interest in science; for example, poor teaching methods such as excessive note-taking or too many ICT-led lessons found in comments such as *I just didn't like the way we were taught science…there were quite a lot of videos which made it quite hard to write stuff down G16 FNC.* Students also talk about how the teacher is unable to make lessons interesting and that this affects their enjoyment of science leading to decisions not to take it further. For example a student talks about the reason she was put off taking science further; *the way we were taught, it went from all being kind of fun and having a really fun way about it and it was all of a sudden power points…and no-one was really excited for science G8 FNC.* Some students perceive their interest decreases when teachers fail to provide **stimulating or inspiring classroom environments**. This may arise because of personality clashes with students as well as teaching practice; for example, *I got a teacher and she just put a downer on science for me…it was both her and the way she taught; I think it was just really boring C14 FNC.* Students prefer teachers who make the lesson interesting as illustrated by *if the teachers aren't fun then I'm not going to enjoy science C5 MNC.*

Two aspects of teacher influence made visible in this study is the **disruption** caused by unruly peers and **teacher absence** resulting in students being taught science by supply teachers. Both aspects (discussed in detail in section 6.4.2.2) have been offered as the reason for students' decreased interest in school science. Although both themes are clearly related to teachers, and almost certainly impact on interest, it is also likely that they work through impact on student success. This and other issues which might be loosely placed under teacher influence illustrate the difficulty of any simple mapping of

[61] This may be due to the characteristics of the sample that was interviewed e.g., they may have had a less positive experience of teachers in comparison to the whole sample that was surveyed.

students' themes onto the three key factors (ISV).

Finally, although a majority of students talk about interest in science arising from school factors such as doing science experiments and being taught by enthusiastic teachers, a small minority of students also point to their **intrinsic interest** in science as being a key reason that they took science at A-level. For example, *I've liked science for pretty much as long as I can remember R1 MSF.* The main non-school factor that students mention in the surveys and interviews as influencing their interest in science is television programmes. Some students talk about their early interest in science as having started when they watched medical and forensic dramas on television and this coupled with reports of intrinsic interest in science are the main non-school reasons for their interest in school science.

At the risk of repetition it is important to stress that these sources of influence on decisions to take science and themes in students' accounts of their school experience cannot ultimately be treated independently. Thus, for example, interview analysis points to a close relationship between curriculum content and teacher influence. Although teachers can influence interest in science in a variety of ways - through their teaching methods, their ability to form relationships with students, the way they manage classrooms and even through their absence or presence - the way they interpret the curriculum also has a major impact on the way students perceive science. A large part of students' narratives involve how their teachers helped increase or decrease an interest in science; particularly the way teachers put across science subject matter.

In addition to these important school-based influences, interest in science is also influenced though probably to a lesser extent by **non-school factors** such as television programmes though such comments are rare amongst the interviewed students, possibly because of the school focus which had been signalled. There is also a need to recognise that there is a difference between school science and science generally; however, of the students interested in science few mentioned an interest in science generally apart from the those who talked about interest in science arising from television programmes (n=5).

7.3.2 Success in science

In the surveys, examination results are the most significant factor in scientists decisions to take science after GSCE with 52% of students indicating that **exam results** are the main influence on their choice (see figure 6.1). The interview data mirrors this finding where a large number of scientists indicate that their success in science at GCSE has influenced their decision to take science. For example *I chose these subjects (science) because they were my strong points from GCSE R2 MSF*. Reference has already been made in the section above (7.3.1) to the importance of **attainment in examinations** to the decision to pursue science further. This might be judged the most obvious focus of student decisions. However the analysis of interview data, suggests that it is not the only component of the notion of success. Student narratives of success in science are characterised by their **perceptions of science being a difficult subject**. Both influences are important themes in students' discourses; however, schools can also arbitrate what is success in science directly through **entry conditions** in science subjects. For this reason, I suggest that in all cases of science take-up, success in science is essential; if students do not achieve the required grade, they are not able to take up science at A-level because of minimum grade thresholds required by school policy.

The literature review suggests that science is a difficult subject and gaining high grades requires more work than some other subjects; perceiving science to be too difficult is enough to make some students doubt their ability to succeed in science and in the case of these students the lack of confidence leads to a decision not to take science. As has already been noted, students' judgements of success or likely success are not made independently of other perceptions of their experience of science. Thus a small minority of students talk about interest in science and how it has made them successful *I enjoy biology so I'm doing pretty good at it; if you like the subject you are more motivated to do it C16 MSF.* The reverse could of course also apply: students judging their lack of success as merely a consequence of their lack of interest. For example, *if you don't enjoy it you can lose interest and eventually you won't get the grades you need C16 MSF.* This is another illustration of the complexity of the network of relationships between the themes referred to by students and how they were taken up into their judgements about whether or not to study science.

Where a large number of future scientists see themselves successful in science, it is appropriate to observe that success may have worked together with other key influences in informing students ' decisions. However, the interviews highlight that in addition to scientists, there are a smaller number of non-scientists that also talk about their success in science (n= 10). These non-scientists feel they are successful yet have chosen not to take science despite getting good grades in it because some do not have an interest in science. For example, *I dropped physics because the topics aren't that interesting C16 MSF.* A small number of these students didn't take science because they thought that it would become difficult at A-level. For example, *even though I liked biology more, I just didn't want to choose it and not do well at it G8FNC.* They talk about struggling with science subjects and decide not to take science further based on their perception of anticipated difficulty. This suggests that success in science is also underpinned by other influences which are largely personal constructs such as self-efficacy. Again this illustrates the complexity of the network of relationships; when students with good attainment in science (evidenced by good grades) do not wish to take science further because they do not believe they will be successful (for example, the eight non-scientists by choice who have been successful in science). This indicates that success does not act in isolation (see 6.4.1) but that there needs to be an element of interest and /or value which encourages take-up of science.

7.3.3 Value of science

Value of science is the term used to describe the third focus of students' decision-making in science. This term is applied to student statements about the importance of science for their future career goals or for some extrinsic reward such as praise to be indicative of a ' utility value of science'. From the literature review and from personal experience, it was expected that some students would regard science as a valuable subject and decide to take science to help gain entry to good universities for non-science courses; however, this was not a prominent theme in this sample of students. The main utility value of science perceived by the students is **career goals**. For example *I always knew I wanted to do science because of my career choice C2 MSF.* There is a rare example of a potential scientist for whom the value of science is *so that I can prove that I can do it C13 FSP.* But this example was exceptional in relation to other comments about value of science.

Of the future scientists interviewed, in each case these students made it clear that their future science career goals had played a critical role in their decision to take up science. Evidence for this is seen in comments such as *it's a deep passion I had since I was five and I was in an aeroplane …and ever since then I've just had a deep passion to do anything with flying C2 MSF.* Similarly, another students says *I always wanted to be a doctor; even when I was little C6 FSF.* Students like this have science career goals from early in their lives and often know whether they are going to take science or not after GCSE from an early age. In contrast, a several non-science students interviewed (n=14) claim that science is not relevant for their career and this is the reason they decided not to take up science in the future. Also apparent from the discourse of non-scientists is the feeling that science is not a subject that is needed; for example *it is not for me R3 MNC*. These kinds of claims suggest that school experience might not be impacting this key focus of student decision-making.

Sometimes science career goals need to be changed because of lack of success in science as illustrated by; *I was set on doing medicine and it was going well, and I was easing through the courses and I was getting the top grades without really trying…I just thought it would be really easy again and I sort of just relaxed, just took a step back and let it go on. And then I found out that wasn't the case and I just flopped the whole thing C11 MNE.* Here, despite having a science career goal, the lack of success in science has forced this student to take non-science subjects at A-level. This signals that having a career goal in science has to be accompanied by success in science for a student to take science further. Further evidence for this is noted in the non-scientists by exclusion group of students (see appendix P) where a number of students have had science career goals but not able to take science further as they have not gained the requisite grades to take science post-16.

To **summarise** this whole section, the themes emerging from the student interviews about school science experience (Chapter 5) form part of a complex network of influences which impact on student decision-making. The three factors – interest, success and value of science – seem to mediate this decision-making process and are the key drivers of student decisions to take science or not after GCSE. There is evidence that none of the three factors operates on its own; for example success has to be accompanied by interest and/or value for a student to decide to take up science.

7.4 The notion of resilience

From the findings that 22% scientists have a regressive trajectory and 27% of non-scientists have a progressive trajectory in their school experience of science (see section 5.2.1), a question is raised about why some students who have had a less positive experience of school science decide to take science further whereas other students who seem to have had a more positive experience of school science do not want to take it further. Although these two situations seem to be converse, it is suggested here that they are influenced by different mechanisms of the ISV factors. In this section, I will attempt to explain the underlying reasons for both these situations through the speculative concept of resilience that is supported by student comments about their decisions to take science or not further. I am using the term 'resilience' here to refer to a situation where students thrive academically despite adverse circumstances; and exactly what resilience means in this study's context is that when student experiences of school science have been less positive, some students are still willing to take up science after GCSE.

Table 5.1 shows that 59 scientists have a regressive trajectory in their storyline graphs suggesting that these students have had a negative experience of school science yet still chose to take up science after GCSE. The surveys provide limited further detail about this (see below) but interviews with three of these students – all future scientists (C3, C8 and C9) helped gain insight into why they took science despite having negative experiences of science. In the case of C3 (see Andrew's student profile in 7.5.2 below), his career goal to become a neurologist and his success in science have compensated for his poor school experience[62]. C8's experience of school science follows a regressive trajectory because he felt demotivated by the lack of science

[62] This poor experience of school science occurred while he was at another school and not in school C.

experiments as he progressed through secondary school. In his case, the career goal of becoming a dentist and his relative success in science compensated for this less positive experience. For C9, science topics taught in GCSE caused a negative experience of school science in the later secondary school years. In his case, a science career goal compensated for his[63] negative experience and he persevered with science to A-levels. It is seen here that having a career goal in science along with relative success in science can act as compensation for a poor experience in science.

It is acknowledged that these three future scientists are a small sample of 59 students with regressive trajectories that have gone on to take science and that the mechanism of resilience may not be similar for the other students in the surveys. But there is evidence within the data which provide some insight into the reasons for a poor experience in school science by looking at student low points and school factors influencing science choice from the survey questionnaire. 32 of the students claim their low points are because of curriculum content, 20 say it is because of teachers and 8 say it is because they were not interested in science. For the biggest influence on their choice to take science, 14 students[64] indicate that school did not influence their decision to take science while 9 indicate the biggest influence on their choice of science was because of their career and 12 students took science because of their examination results. This shows that a large majority of students have been influenced by career goals and success in science to take science at A-level. Across these cases there appears to be a pattern that is broadly consistent with the idea of resilience as that term was defined earlier; the notion that resilience relies to some extent on science career goals and success in science. Here the evidence suggests that students who are successful in science and have career goals in science will take up science despite having negative experiences.

A different situation arises with the finding that 27% of non-scientists have a progressive trajectory (see table 5.1) indicating that some students will not take science even when they have had positive experiences of school science. In this case it

[63] Although these three examples are all male; of the 56 remaining students, 29 are male and 26 are female (one student left gender blank)
[64] Of these students, 6 indicate it was their science career choice, 4 indicate television programmes and 2 indicate it was their interest that led them to choose science.

is important to look at ISV and how students may form their judgements about not taking science. In 7.3.1 it is seen that an interest alone in science is not enough for students to take up science in the future, it has to be accompanied by success in science. The discussion in 7.3.2 suggests that success is not just limited to attainment but also to the perception of success in science; just gaining good grades in science is not enough to lead to a decision to take science, students need to perceive they will be successful at science in the future too. Therefore there is a possibility that students may have had positive experiences in science but do not feel confident enough to take science further (see 6.4.4 for student comments). An alternative explanation for this finding is seen in section 7.3.3 above where students explain that they do not have science career goals and that this has been the reason they have chosen not to take science. In this case, it is reasonable to expect students with positive experiences of school science who may also have some interest in science and be relatively successful in science to choose not to take science because they have non-science career goals.

7.5 Patterns of influence on individual students

In this section I will try to illustrate as far as available data allows, how the key factors impact on decision to take science discussed above (ISV) and the influences on students experiences of school science play out in particular students. The section is organised loosely around the four trajectories explained in the first section above and in chapter 4, because they come closest to a framework for sampling types of school experience[65]. The purpose of this section is to offer examples of the complexity of school science experiences and decisions to take science; showing how school and other influences are mediated by ISV factors. This will be illustrated through what I will call student 'profiles' as described below.

7.5.1 Creating student profiles

Since this section deals with decisions to take science, the natural division of students is to group them into scientists and non-scientists as defined earlier. The student profiles in this section are based on the trajectory divisions described in table 7.1 above.

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[65] A progressive trajectory resembles a positive experience; a regressive trajectory resembles a negative experience, a PUD trajectory resembles a variable experience and a stable trajectory resembles a stable experience.

Scientist	Non-scientist
P	P
R	R
PUD	PUD
S	S

Each of these profiles is described in terms of the factors (ISV) in the previous section since it is a useful way to understand students' decision making processes and positioning school influence within it. It is important to reiterate here that ISV are not discrete entities but they have a relationship with each other and these relationships will be highlighted in the appropriate places.

7.5.2 Students choosing science after GCSE

Priya

Priya (G1) talked at length about her subject and career choices. She is taking maths, biology, chemistry and physics at A-level which puts her in the group of future scientists. She has a progressive trajectory of school science experience.

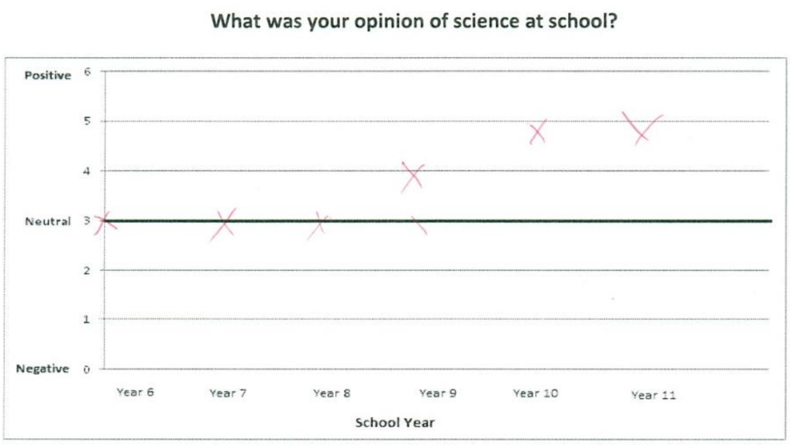

Fig 7.5 Progressive storyline graph trajectory – Priya

Interest

Priya's trajectory indicates that she has had a positive experience of school science; when asked to describe her experience she explains that her trajectory is progressive because she found science both easy and fun:

> *In year 7 it was like really easy stuff that they taught you so it just made it really fun you understood it and in year 8 and 9 its cos we had a we had like a really*

> *laid back teacher…I think he was really fun and he like made teaching, he made science really fun.*

Her interest in science seems to be mediated by her perception that it was easy in the earlier years and this is a common reason amongst the students in this sample when explaining their high points in the earlier years of secondary school. When asked to explain the things that made her enjoy science, Priya comments about the topics in science that she enjoyed;

> *In chemistry and biology I think it's the topics that are there; they are quite interesting. Like last unit there was for biology my teacher was teaching about the heart and stuff so I was like I got really interested In that so that's like kInda made me decide what to do In university like going to cardiology and stuff.*

Priya's interest also seems to be derived from teacher influence; she liked the teacher she had in Years 8 and 9. She felt that the teacher was accommodating and funny which made learning science easy. Priya emphasises the impact that teachers have made on her interest in science throughout her interview;

> *So yeah then in all the subjects the teachers are really fun and stuff like for last year physics I had like a really fun teacher yeah so that's why I feel like high expectations for this year's physics.*

The way that her teachers have made in impact is not just through encouraging an interest in science but also through helping understand the subject as is seen in below.

Success

When questioned about her enjoyment of her current A-level science subjects, Priya explains that she is not enjoying physics as much because it is a difficult subject to understand;

> *Physics is just like...physics is okay...it's just getting like really hard so I'm like not enjoying it as much.*

These comments indicate that for Priya, interest is related to success; because she is finding physics a difficult subject her interest in the subject has waned. Although Priya talks about how her A-level subjects are more difficult, she emphasises how her teachers are helping her to cope;

> *For now, it's still quite fun but stuff is getting harder and stuff like more pressure is being put on because it's like A-level and stuff but I think the teachers make it like quite bearable.*

This influence of teachers on success seems to contribute to a compensatory effect; Priya finds A-level physics difficult but because her teacher is good and makes physics interesting, she is able to carry on with physics for the time-being.

Value

Priya indicated in the interview that she wanted to become a doctor in future. Her career choice of becoming a doctor has been influenced by several things;

> *My dad always wanted me to go into medicine and stuff; he'd always tell me stuff like how doctors save lives and stuff and I mean like he did come home and like he was a nurse and he'd come home and tell me stories like what he did and stuff. So I was like, God that's really good; I want to do that when I get older.*

Here it is seen that her father influenced a choice to go into medicine; but Priya also indicates that apart from this there is also another influence;

> *Probably like year 9 I started like watching more TV like medical dramas yeah and like I used to think like God I wish I could do that. I know it's not the same and stuff but I mean like it's got the general idea.*

A few students in this sample mention that particular TV programmes have made them more interested in particular career pathways; from the comments above it is seen that TV medical dramas also provided an incentive along with parental push. A third influence also emerges when Priya emphasises how school science made her decide to take science further:

> *Probably because I was kind of into arts and stuff, and then I wasn't quite set on doing medicine but 'cause the teacher was so much fun, it was like oh I might be like really good at art and stuff but I could learn more with science and it*

would be like so much fun with the teachers and stuff and it would be really good.

Although she was good at art, Priya decided to ultimately take science subjects as she liked the teachers and because of the incentive provided by science to learn in more detail about her interest in medicine.

Thus, Priya is an example of a student who has been influenced by interest and value in science to persevere with science despite the difficulties she is facing with physiscs.

Andrew

Andrew (C3) is a scientist with a regressive trajectory who is taking two science subjects at A-level along with maths and French.

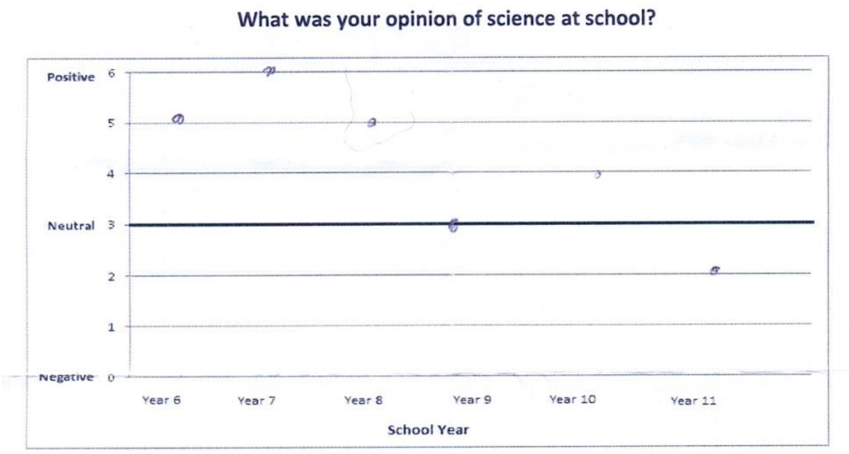

Figure 7.6 Regressive storyline graph trajectory - Andrew

Interest

Andrew's trajectory starts high in the early years of secondary school and then becomes progressively lower; Year 11 is his lowest point. In the survey, Andrew writes about boring aspects of green chemistry and ecosystems as the reason for his low point. In the interview, talking about his lowest point in Year 11, Andrew says:

It was too much coursework and exams, teachers weren't really good for me, so I didn't really like science that year but it didn't put me off it because I got my grades in year 10. And all there was left to do was year 11 coursework and I done my coursework well.

Andrew's highest point was in Year 7 and he writes in the survey that this is due to the emphasis on experimental work in schools. In the interview, he explains that there was a lot of practical based work in Year 7 and that this is when he used Bunsen burners a lot. He explains that practical work is the best way to learn and that the reason for his regressive trajectory is that during the years after Year 7, there was a lot more theory work and fewer practicals.

Success

Andrew mentions that he did well in science in Year 10 and that he also did well in science coursework (see comment above). A significant point emerging here is that although Andrew is bored by certain topics in science and thinks that there is too much coursework and examinations as well as not liking the teachers, he is still able to take science because of his his achievement in science in which he did well. This is an illustration of the idea of 'resilience' in the sense that the term was used earlier.

Value

In the survey questionnaire, Andrew indicates that he made a firm decision to take science in Year 9. He explains that he always wanted to be a doctor in the army; this interest arose from watching films and seeing doctors saving lives. In the interview he talks about wanting to become a paediatric neurologist and his comment below hints at the influence that encouraged this career choice:

> *Since year 9 when I went to St Georges hospital with my old school and I was there for a week and it was quite interesting and Great Ormond Street hospital, I love what they do.*

Andrew indicates that he does not feel that school has had an influence on his choice to take science. In the interview he explains that he had gone to a school that was doing poorly in the league tables and that there was not much good teaching; he learnt most of the subjects for GCSE by himself because he '*set his head to it*'. In his present school, Andrew feels supported and challenged; he comments that the teachers are good and that his Head of Sixth form has provided support for his interest in becoming a doctor. Here the lack of interest in certain science topics and the poor teaching Andrew experienced in a previous school do not seem to have put him off taking science in the future. It is suggested that Andrew's future science career goal and relative success in science may have a compensatory effect on his choice to take science relating to the notion of resilience.

Anil

Anil (G14) is an articulate young man who answered interview questions confidently and in a lot of detail. Taking two science A-levels and indicating that he is taking science at university, places Anil as a future scientist. He seemed to be confident with his choice to take science and his future career goal. His storyline graph showed a PUD[66] trajectory indicating a variable experience of school science.

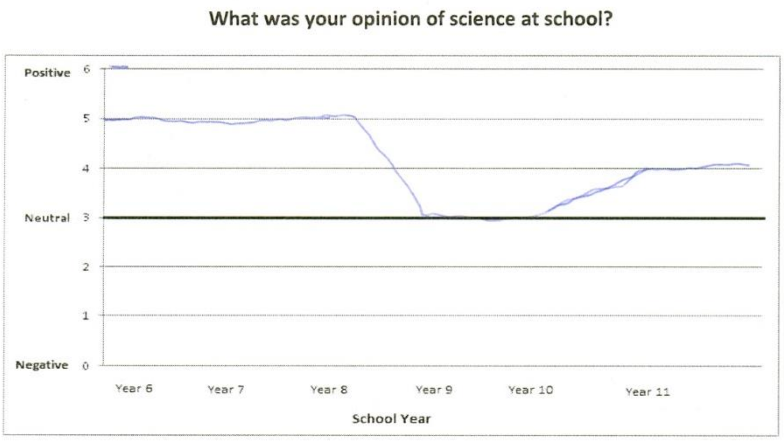

Figure 7.7 PUD storyline graph trajectory - Anil

Anil is taking chemistry, physics, maths and further maths for his A-level subjects. In the interview, he says that his decision to take physics was because he always wanted to do engineering and maths. He chose further maths because he wasn't sure if ICT was a good subject to take or not for university admissions.

Interest

In the survey questionnaire, Anil indicates that school science has influenced his decision to take science and that the teacher has had the most influence on this decision. Explaining this in the interview, Anil says:

> *I feel that they both (chemistry and physics teachers) were really good teachers and they were really enthusiastic and that opened me up to doing physics and*

[66] This is classed as a PUD trajectory as a default (one of five such trajectories)– it does not fit the criteria for P, R or S trajectories and has been placed as PUD by default.

chemistry because I felt if they have a enthusiasm for it then there must be something to be enthusiastic about. The energy that was taught with by my teachers has influenced me to do it (science) in the future and that is what I feel makes me want to take it in the future.

As the reason for his low points in Years 9 and 10 Anil writes that having to study cell biology instead of human biology made him less interested in science and this was why his graph dipped in those years. In the interview, Anil explained that he felt enthusiastic teachers had an influence on his interest in science; talking about the low points at Years 9 and 10 he says:

I feel that the teaching in year 9 and year 10 wasn't done with the same sort of excitement as it was with the other years.

He also emphasised his dislike of biology topics when explaining that his choice not to take biology at A-level was due to the course content. Thus curriculum content and teacher influence are the two main sources of his negative experience of school science, in both cases through having an impact on his interest.

For his high points Anil writes 'practicals'. When asked to elaborate in the interview, he explains:

Year 6 science was something I was looking forward to because I first found out that we were going to do practicals and I was really excited that we were going to do something, which wasn't just sitting in a classroom looking at questions which were really boring. In year 7 and 8 I feel that when we did do the practicals it went pretty well and it was enjoyable and we had plenty of time with Bunsen burners and reactions; not that we knew much about the content but it was fun and it was something that made me want to go to science lessons.

His interest is positively impacted by school practical work; this reason for motivation to do science is seen in a large number of students in this sample. Anil talked about Year 6 having few practicals of consequence and looking forward to joining secondary school to do experiments in a school laboratory. Having experienced practical experiments, he recorded a high point in that part of his storyline graph, indicating a positive experience. It is a good illustration of the influence of science experiments being mediated through interest.

Success & Value

Success and value are described here together since they are difficult to unpick from Anil's interview. In the survey questionnaire, Anil indicates that he made a firm decision to take science at the end of Year 11. When asked about this in the interview, he said that he had no firm university or career goal in mind before then. In Year 10 he thought that he would become a language student and take French and German. At the end of Year 11 when he got his GCSE results, he decided to take physics and maths at A-level to take an engineering course at university. However, some months into Year 12, he changed his career focus. When asked about the reason for changing, he explains:

> *I thought that from the end of year 11, that was something I wanted to go into but I feel that it was after a while of doing physics, I felt like it was something I couldn't do and it wasn't practically interesting.*

Thus, being successful in GCSE science led Anil to decide to take physics at A-level for an engineering course at university. However, talking about his A-level choices, Anil explains that chemistry practicals are more interesting than physics practicals and that this influenced his decision to switch from engineering to chemistry. Here success is seen to have a relationship with interest; Anil feels less confident in his ability to do physics and also finds that he is not interested in it as a subject.

Thus, although there are elements of success and value in Anil's discourse, the lack of interest in physics practicals as well as a lack of confidence in his physics ability has led Anil to choose a chemistry career over his earlier plan to take up engineering at university. However, good examination grades and a value for science have ensured that Anil remains on a science pathway.

Simon

Simon (G5) is taking only three A-levels in Year 12 and therefore has no choice to drop any of the subjects upon transition to Year 13. He is taking physics as his science A-level along with maths and IT. Simon's storyline trajectory is interesting as it does not show any highs or lows during his time at secondary school. This is noteworthy as it indicates that his experience of school science has been consistently similar over the five years he spent at secondary school.

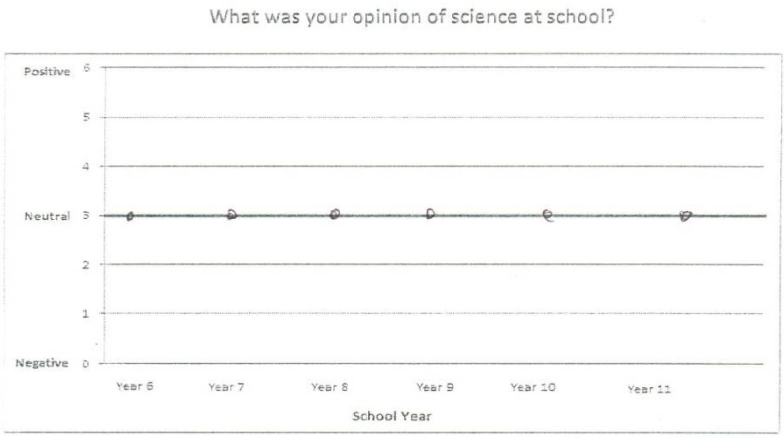

Figure 7.8: Stable storyline graph - Simon

Interest

Contrary to the experience depicted by the trajectory – that there was no difference in school science experience, Simon explains that his interest in science started later in Year 10:

> *Well in year 7, 8 and 9 I didn't really like... well I messed about more and then when you realise that you have a future and stuff, that's when I realised that I do find physics more interesting, to know how stuff in the world works and stuff that's why I liked it.*

Simon's comments about realising that he had to think about his future progression show that he came to a decision to start concentrating in his lessons. He found that he enjoyed physics because it interested him to know about how things worked and was relevant to his life. When asked about his other science subjects, Simon explains:

> *Well I didn't really like chemistry to be honest the formulas of remembering all the chemistry stuff, I didn't really have an interest in chemistry but physics was interesting, biology because I took PE and biology linked to that which was pretty good.*

This suggests that having an interest in learning specifically about how things work have relevance for him and influenced Simon's liking for physics; whereas not having an interest in chemistry or finding it relevant has influenced Simon's dislike of chemistry. Similarly, he finds that learning biology is relevant for PE and therefore feels that biology is a subject that he is interested in.

When asked whether school science had any influence on his choice to take science subjects after GCSE, Simon explains:

> *No not really to be honest, I don't think that.... I had an interest in physics and that's it.*

He thinks that his own intrinsic interest has helped him become interested in science and that this has nothing to do with his experience of school science. He further emphasises how his interest in science has helped him become better at learning science:

> *When you're trying to learn it and obviously if you have an interest in it, it's going to help like... help you learn it better. Rather than being bored I actually find it interesting and actually do better.*

Simon's comments are typical of other students who have stable trajectories in their storyline graphs (n=29); a majority indicate that school science has had no influence on their choice of science subjects and that it is their intrinsic interest in science that helped them choose to take science.

Success

About his success in science, Simon's comments:

> *Well I wasn't too good at science in year 7, 8 and 9 but towards GCSE's I started to take more of an interest in it so.... I got moved up to a higher group so I started to like it and that's why I wanted to take physics for A levels as well.*

The relationship between interest and success and their central role in his decision to take science is highlighted here; when Simon became more interested in science, he feels he was moved to a higher group and then he started to like science and this led to his decision to take physics at A-level. There are many strands to be unpacked in this complex relationship. Firstly, Simon feels that he wasn't successful in science in the early years of secondary school; this may have some relationship with his behaviour that he describes above as 'messing around' in science lessons. He then came to a decision to stop messing around and concentrate on his future. At this point, he realised that he was interested in physics and started to be more successful. He was then moved up into a higher group for science. This had helped him get better grades;

> *Yeah I think that did help because..... If you were in middle or bottom set maybe the teacher don't give you as much hard work, so they don't think that you will be able to do the work at A or B grades, being in the top set the teachers help you a bit more.*

Once he felt that he was recognised as being good at science, his confidence rose leading to a decision to take science further. Simon's comments show that success and interest have a very close relationship and that both can lead to a decision to take up science further. Where Simon, has not been interested (in chemistry), he has not chosen to take chemistry further although h has had the chance to do so because of his success in GCSE science examinations. It is suggested in Simon's case that success in science is not the only criterion for science subject take-up but that an interest in the subject is also necessary. There is also evidence that utility value has had an influence on Simon's choice of science at A-level which is discussed below.

Value

The value of science in Simon's discourse is not characteristic of the usual way other students indicate in terms of valuing science as a career goal. Simon's version is evidenced in his comment;

> *Well I think it boosted my confidence to be honest..... Middle set isn't really that good but being top set it's like the teachers recognise that you are good.*

Being in the top set made Simon feel that he was recognised for being good at science and it is suggested that he feels 'rewarded' for doing well by being recognised for being good by his teachers. He feels that this increased his confidence in science as well as his interest in the subject. Above it is discussed that although Simon's success in science gave him the chance to take up all three science subjects at A-level, he chose to take up only physics. Simon's narratives indicate that he didn't enjoy chemistry and this may have influenced his choice not to take up chemistry at A-level; however, he does express an interest in biology as being related to PE. His decision to become an engineer may explain his A-level subject choices:

> *I really thought I was good at maths and I looked at engineering courses and what is involved with it and I thought it was quite interesting and then I show physics sand IT they need to be like...... and I didn't mind physics and IT I think I'm alright at that.*

Simon's decision to become an engineer may have influenced his decision not to take biology at A-level as he no longer needed biology to help him gain entry to the course of his choice at university.

Thus, in Simon's decision to take science, it is seen that all three ISV factors have had an influence on his take up of physics at A-level; he has taken up physics because of its utility value for his future career and because of his success and interest. His lack of interest in chemistry and the lack of its utility value in terms of his future career may be responsible for his decision not to take science even though he is successful in that subject. He is also successful in biology as well as having an interest in it but the lack of utility value for the subject has led to a decision not to take it further.

7.5.3 Students choosing not to take science after GCSE

Anna

Anna (C10) is not taking any A-levels and is classified as a non-scientist by choice. She is one of a group of five non-scientists who indicate they have had positive experiences of school science but have decided not to take science any further after GCSE.

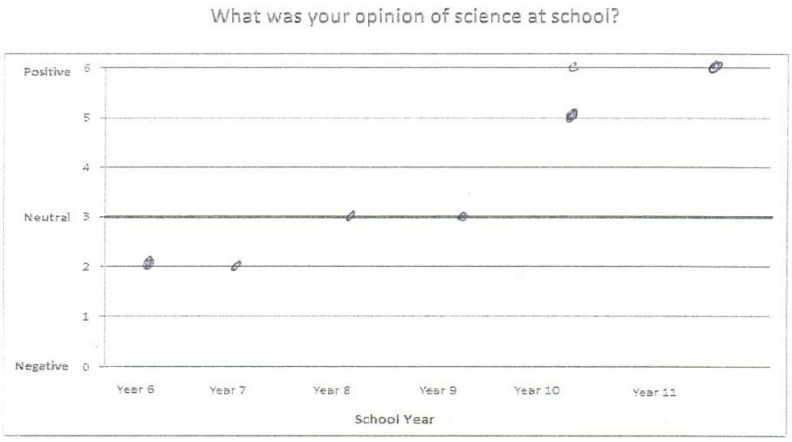

Figure 7.9 Progressive storyline graph trajectory - Anna

Interest

Anna's storyline trajectory shows that her early experience of school science was not positive and in the interview, she explains her early low points in her storyline graph:

> *I hated school science in year 7 it was only because I didn't have a teacher.*

She explains that her poor experience of science was because of a lack of regular teachers for science;

> *My teacher got pregnant in year 7 and we sort of had a supply teacher for the rest of the year.*

This narrative shows that Anna became disengaged from science due to a lack of good teachers in science which also affected the interest she had in the subject;

> *I did all the work before by myself because I didn't have a solid teacher. I stopped listening after that in year 9.*

Further in the interview there is evidence of other influences on her lack of interest and enjoyment in science;

> *I hated the fact that we had quite a lot of exams like mocks and the module exams. We had at least four exams a year for each module. I didn't really like that.*

This comment indicates that along with lack of good teachers influencing her decreased interest in science, Anna is also influenced by the examination-driven content of her science subjects.

About her gradually progressive trajectory, she explains that her highest point in Year 11 was because of her teacher:

> *I had quite a good teacher in year 11, I got a new teacher from Canada and I really liked him. I liked my lessons with him…and I also moved up in group as well. That's when I started going to the after school classes and that really help me get a C, I really didn't think I would get that.*

In the interview she explains about why she thought her Year 11 science teacher to be a good teacher;

> *Because he gets you involved rather than just writing on the board and telling us to copy. He just really got the class involved which really helps when you're in an exam… I hate having to write from the board.*

The interview shows that Anna was influenced by teachers in her experience of science; this is corroborated by evidence in her survey questionnaire where she indicates that teachers are the greatest influence on her decision to take science. Anna's narrative about interest also has a relationship with her feelings about success in science as seen below.

Success in science

Anna's narrative about success in science is evidenced in the following comment;

> *In year 8 I got moved up but they didn't know what group to put me in to, I was never in the bottom group always in the middle group. They put me in the top group for year 9 and I didn't know what to do with that.*

This comment shows that she may have had reasonable success in science but did not really feel confident about being put into a higher group for science. When asked about how well she had done in science, she says about her SATS examinations in Year 9;

I don't think I done very well on those on science. All I know is that I struggled.

About her GCSE examinations in science she says;

I got a C. So I didn't do that great but I was on foundation paper so that was the best I could get any way.

Anna puts down her lack of success to the absence of having a good teacher in lower school;

My sister took sciences and she had a very good teacher, she got an A. I think it would have better if I had a better teacher earlier.

The influence of teachers in Anna's narrative is not only specific to her interest in science but also has an effect on her success in science. On the one hand, poor teaching contributed to lower grades and decreased interest in science while on the other, her teacher in Year 11 has led to an increased interest in science and relative success in science. However, this success was not enough to allow her to take science at A-level;

I didn't mind chemistry but I didn't enjoy it enough to take it as an A level. Plus I didn't get the grades to get in to chemistry A level because you have to get a B or Above.

Not only did she lack the interest to take science, Anna did not achieve the required grades to enable her to take up science at A-level. However, the section below indicates that utility value of science has also played a role in her decision not to take science.

Value

About her subject choices at A-level, Anna explains that she has chosen creative subjects because of her career goal to be a fashion designer.

For as long as I can remember I wanted to do fashion and designing… I want to go in to fashion. I want to do editing and journalism for a magazine.

Here it is suggested that Anna's career goal to be a fashion also has an influence on her decision not to take science.

Thus to sum up Anna's experience of school science; her initial negative experience in school science led to a decrease in interest in science because of teacher influence. Along with this, a lack of success in science and having a non-science career goal influenced her decision not to take science further. Even, when she experienced better teaching later on during GCSE years and her interest in science increased, this influence was not strong enough to overcome the influence of lack of utility value.

Nadia

Nadia (R9) has a regressive trajectory and is not taking science subjects at A-level; she is taking English, ICT and psychology.

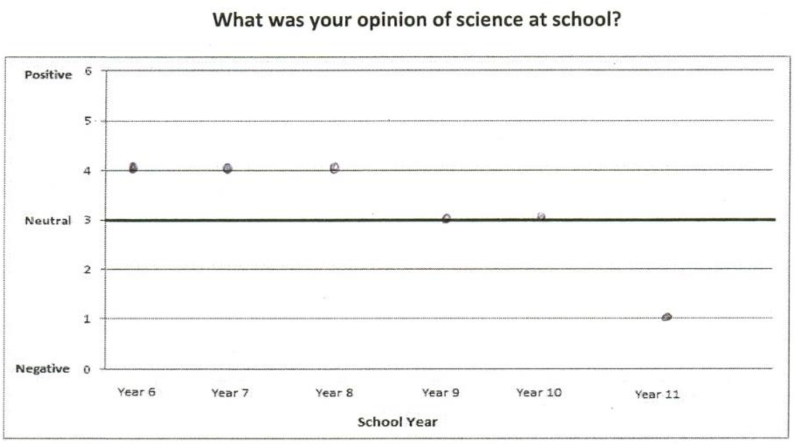

Fig 7.10: Regressive storyline graph - Nadia

Interest

About her interest in science, Nadia explains that her highest points of school experience were at the start of secondary school;

> *Well it started off interesting at first year but then 'cause we have it every day because it's a science college and it got just too boring, and too much work, and I didn't enjoy it.*

This positive experience was followed by a progressively negative experience due to the perceived work load associated with science. When asked about what it was about science that she liked, Nadia explains;

Just all the practicals and just learning more in depth than year 6.

She explains that her most negative experience was in Year 11 because:

It just really got the same and it wasn't a subject that I enjoyed…it was a lot of the same work but just repeating itself, but in more depth…and not many practicals and stuff.

Nadia's main influence on interest seems to be science experiments; she explains that she liked being in Year 7 because of all the practicals and that her later disengagement arose from having to do science every day but not as many science experiments.

Success

Nadia explains that the biggest influence on her choice not to take science was because;

I just lost the motivation from having it every day, so I didn't revise and just failed my exams.

A lack of interest coupled with a lack of success in science influenced Nadia not to take science further.

Value

In the interview, Nadia explains that her parents are both in the police and this is the career path that she thinks she will pursue in the future. When asked about when she became interested in this career path, Nadia indicates that it was quite early on but that she also considered other career paths. Further probing revealed that none of her alternative future career choices involved science.

This suggests that a lack of utility value in terms of future career may also have influenced Nadia's lack of interest in science.

Emma

Emma (R11) is taking no science subjects at A-level. She has a PUD (see footnote 31 p71 for explanation of this) trajectory where her initial experiences at school are more positive than her later experiences.

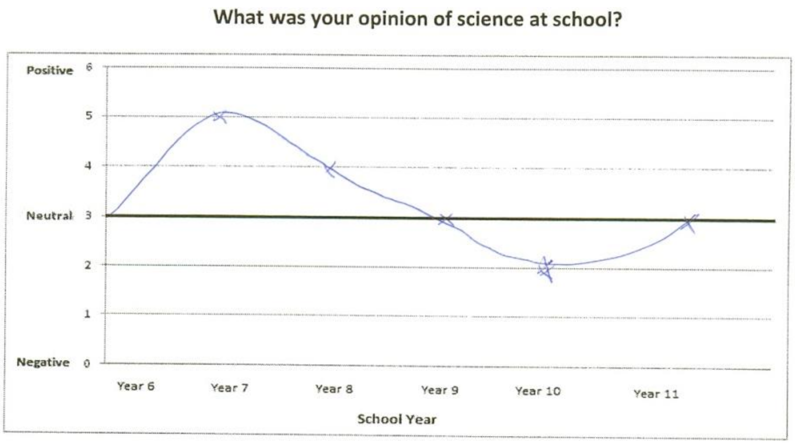

Figure 7.11 PUD storyline graph trajectory - Emma

Interest

Emma explains that the reasons for her highest point in Year 7 were because she had good teachers and enjoyed the subject. She talks about why she felt her teacher was good;

> *In year 7, I had a brilliant teacher…because we were in (mixed) classes so we weren't differentiated at all levels; the teacher did set work on our ability, which was really good because I was one of the top end because I was getting my level 7s, so I got extra work and got projects and stuff.*

Emma's experience of good teaching arose from her feeling that she was stretched and challenged in her science lessons. Although during the interview, Emma mentions teacher influence as influencing her experience of science, in the survey questionnaire, Emma indicates science topics had the greatest influence on her decision to take science.

Emma's positive experience of school science did not last long;

> *…but then in year 8 and 9 I had three different teachers and in year 10 we had loads of supply teachers. We were put into sets and it wasn't differentiated; there wasn't any extra work when you finished. Year 10 wasn't a good year… I was at the top end of set two and I wasn't getting the right work so I just didn't enjoy it*

After poor experience of teaching in Year 10, Emma had a better teacher in Year 11;

In year 11 I got moved back up again and we got a set teacher, so it got a bit better.

In the interview, when asked about how school science made her feel about taking science in the future, Emma says;

…the teachers they're not bad teachers but with other teachers I could go and talk to them, with my biology I felt when I was going wrong I couldn't ask my teacher and as I progressed I felt I was moving away from science.

She also explains other influences on her interest in science;

Some things are taught in a way that are a lot more interesting than others; just things like enzymes and they were taught a lot better in biology than chemistry; so it was mainly to do with the topics, whether I enjoy it or not.

Emma's narrative shows that although she started with an interest in science, school experience of a combination of frequent teacher turnover and poor teaching put her off enjoying science. There is also a relationship with success and utility value of science as discussed below.

Success

About her success in science, Emma comments;

*I ended up getting all A*s in my science GCSEs. That was off my own back, it wasn't any of my teachers. Had to go home and learn all of it by myself; I literally did that by myself.*

Although Emma achieved the highest grades in science, she explains that it was because of her own effort as poor teaching forced her to learn science at home rather than school. However, instead of taking science further, Emma seems to have been put off taking science. When probed about the reasons she chose not to continue with science, Emma says:

I found it challenging, so it was a combination of all things; the teacher, topics, the level of difficulty, or whether I enjoy it or not, I'd have to say the easier it is the more I enjoy it.

Emma's narrative indicates that a combination of influences underpinning success and interest in science have influenced her decision to take science further. In addition to this there is also some influence from her career goals as seen below.

Value

About her career plans, Emma explains;

> *Well in the lower years, I wanted to do medicine; in year 7 and 8 I was like I'm going to do medicine and as I progressed, I thought actually I don't want to do it.*

The reason she decided not to pursue medicine is because she felt her science teacher was not very approachable. Although she was very successful in her GCSE science examinations, her career choice had changed from becoming a doctor to becoming a lawyer and this along with a combination of perceived difficulty and lack of interest is the reason she did not take up science further.

Sam

Sam (G13) is not taking any science A-levels; his trajectory of school science experience is a stable one that indicates he has had a constant experience of school science.

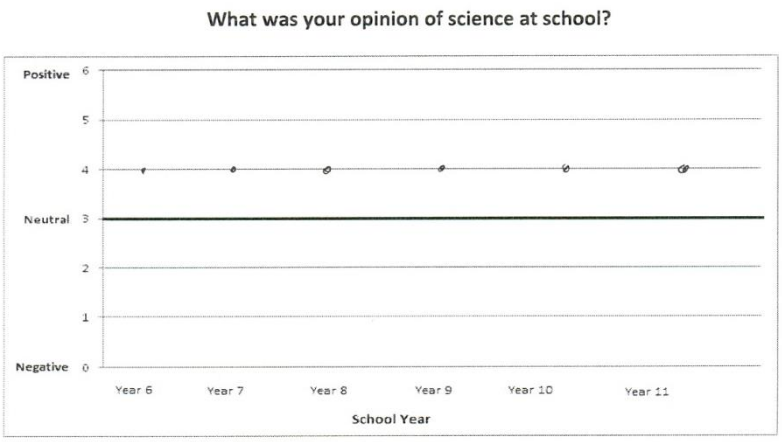

Figure 7.12 Stable storyline graph trajectory - Sam

Interest

About his experience of school science, Sam explains that in the lower year he was interested in science:

I enjoyed it a lot, I was kind of interested and I did quite well in science and I'm kind of happy to do it and it interested me.

When asked about the reason for his interest in science he explains;

…chemistry mostly that interested me with doing chemical reactions and stuff like that and the practical work.

Sam's interest in science is mediated through curriculum content. This interest in science carried on in Year 10 and 11;

In year 10 and 11 I did science and additional science I picked it as a subject which was quite good cos it was more in-depth and I really enjoyed that because just generally I enjoyed it.

Despite Sam's seeming inarticulacy at explaining why he enjoyed science in Years 10 and 11, he seems to have been interested in the topics that were taught in science as well as the practical nature of the subject as revealed here;

I'm not that sort of paper work person I'm more of a practical person.

He further adds about practical experiments in science;

In 10 and 11 you get to do your own experiments whereas in year 7, 8 and 9 you usually do demonstrations and stuff so you kind of get less involved in the experiments.

When asked about his stable trajectory, Sam explains that he didn't really experience any highs or lows that affected his experience of school science and that he enjoyed it throughout secondary school. He makes it clear that he was not really interested in science and that he preferred psychology;

If perhaps there was less chemistry, biology and physics but maybe if they had done some psychology and other stuff that would have been quite interesting.

Although Sam is interested in the practical nature of science, his real interest is in psychology and analysis of the interview data highlights the utility value he assigns to this subject. This is discussed below.

Value

When asked why he hadn't considered taking science at A-level, Sam explains that:

> *Because I was thinking about going on to do like a counselling or some form of youth work or something like that in the future, so that kind of influenced me in not doing a science.*

He indicates that learning about people is more interesting to him rather than doing a science; although he did mention liking chemistry for the experiments and biology because it relates to psychology but it seems that the utility value of doing psychology for a future career in youth work and counselling is the deciding factor for his choice of subjects.

Sam's narrative is similar to another non-scientist with a stable trajectory (R5); he too chose not to take science despite his liking of science because of his career goal to play sports. Both narratives about utility value of science are similar to Anna above who has a positive experience of school science yet has decided not to take science because of her non-science career choice. Compared to other students, the narratives of these students tended to be shorter as they did not have much to say about their school experiences of science or their decisions not to take science.

7.6 Summary

In summary, this chapter had attempted to bring together the findings of chapter 5 about school experiences of school science and the findings of chapter 6 about the reasons that students give for choosing to take science or not post-16. By bringing these findings together, the aim was to explore the role of school science experience in the choice to take science.

There is evidence of a loose relationship between student trajectories and the number of science A-levels taken by the student. The student rating of science in Year 11 is the strongest predictor of science take-up post-16.

Qualitative analysis examines the processes underpinning the quantitative relationships between the school experiences of science and the decisions to take science or not. The various themes arising from student experience of school science form a network of influences that are mediated by the three factors ISV which represent the key criteria for the judgements that students bring to bear in the decision-making process.

The notion of resilience is proposed in which it is suggested that poor experience of school science can be compensated for in certain cases. Evidence for this is seen in the finding that a number of students decided to take science despite having negative experiences of school science. In general students with a career goal in science and who are successful in science will take up science despite a negative experience of school science.

Finally, the student profiles highlight that science choice is based on a rational model of choice in which students' decisions to take science or not are driven by the three key factors ISV. Students in this study tend to take science if they have a science career goal, are interested in science and are successful in science. Students without a science career goal or who are not interested in science choose not to take science despite being successful in science. Some scientists by exclusion have science career goals but are unable to take science because they have not been successful.

In the next chapter, the findings from chapters five, six and seven will be discussed and conclusions will be drawn to inform the implications and recommendations.

Chapter 8 Discussion & Conclusion

8.1 Introduction

The main aim of this study was to examine the role of school science experience on students' decisions to take science or not post-16. The findings were reported in three chapters; in chapter five survey questionnaires and interview data were examined for student judgments on their school science experiences and to understand the high and the low points of students' secondary schooling. In chapter six, students' reasons for deciding whether or not to study science post-16 were examined with a particular emphasis on school-based influences. And in chapter seven, analysis of data from both strands helped conceptualise a framework that would support understanding of the role of school science experience in student decisions to take science or not.

In this chapter, I summarise what this study has shown in relation to the research questions. In the first section (8.2) the research questions are discussed; tying together the different strands of chapters 5, 6 and 7 to offer answers to the research questions. The next section (8.3) describes how the study relates to the research literature by referring back to chapter two to show how it fits in and extends understanding of school science experience and choice to take science or not. In section 8.4, I evaluate the study and identify the limitations of the research. Then I consider the implications of my findings and suggest some possible areas for future study.

8.2 The research questions

Chapter 1 started with an acknowledgement that although there are a number of researchers who have taken different perspectives to explain how students track along different subject and career paths, few have attempted to take account of the broad varieties of ways that schools can constrain or facilitate particular subject choices. This weakness in the literature formed the basis of the main research aim to explore student experience of school science and its relationship to post-16 science take-up.

Also, in the introduction to this thesis, three research objectives were described for undertaking this research.

1. To listen to the student voice about their informal experiences of school science using a novel method of collecting data about school experiences
2. To add to the few research studies that examine students' experiences of school science in the English context and to contribute to the growing number of studies that examine influences on the decisions to take science or not
3. To examine the relationship between school science experience and take-up of science and to gain insight into why some students choose to carry on with science while others do not

How the first research objective of this study has contributed to the research field has been discussed in section 8.2.5 below. The second research objective is described in section 8.3 and the third research objective is described in this section (8.2).

The aims and objectives of this study were addressed through three research questions that would help examine the student perspective:

1. What are students' perceptions about their school science experiences?
2. What are the reasons students give for deciding to study or not to study science post-16?
3. What role does school science experience play in student decisions to study or not study science?

Below, the major findings of each of these research questions are described along with a discussion of their importance and their relationship to similar studies.

8.2.1 Research question 1

The literature review indicates that school experiences are crucial in attracting young people to a career in science (e.g., Smyth and Hannan 2006). It is important to examine what students feel about their school experiences of science to understand how they are useful in their career decisions. The first research question addresses this gap in the literature.

Chapter five of the thesis presented the findings from students' discourses about their school science experience collected from interviews and from the storyline graphs in the survey questionnaires. While the surveys provided a general view of student experiences, the interviews examined finer details of the student experiences of school science. The major findings are discussed in the subsections below:

8.2.1.1 Student experience of school science

The survey questionnaire used a modified version of the storyline instrument (discussed in 4.3.1.1) which collected quasi-longitudinal data about the high and low points of the school science experience of each student. These points formed a trajectory which reflected the student's experience of school science.

The first main finding was that a pattern is discernible where a large number of scientists have progressive trajectories and a large number of non-scientists have a regressive trajectory (see table 5.1). Based on the assumption that trajectories of storyline graphs reflect the overall experience of a student, this suggests that scientists have a more positive experience of school science than non-scientists. Although trajectories of individual students show variability, the average pattern (figure 5.1) is that the trajectories for scientists becomes more positive as they progress through secondary school while the pattern of trajectories for non-scientists does not change much, staying slightly positive throughout their years at secondary school. The main assumption in using this tool that the trajectories of the storyline graphs reflect students' experience of school science; therefore scientists seem to have a more positive experience of school science compared to non-scientists.

8.2.1.2 Student descriptions of high and low points in school science experience

The second assumption in this study is that the high and low points depicted by the students are important events in their school science experience. Qualitative analysis of these points (4.8.1.2) resulted in the emergence of six themes that describe student experiences of school science. The number of times each theme was found in the survey questionnaires as a reason for a high or a low point gave an indication of its significance. From the six themes (see figure 5.2) it can be said that for the sample of students in this study, curriculum content, interest, teachers, perception of science, attainment and classroom environment are the main elements of school experience.

A noteworthy finding from the high and low points of student experience is that the themes emerging from students' accounts are of a bipolar nature – good teachers are the reasons for high points and poor teachers are the reason for low points. This is the case for all the themes that emerged (see table 4.7).

Curriculum content is the most commonly quoted high point (table 5.4) and interview data provides detail of the aspects of curriculum content that is of most significance. Students mentioned their enjoyment of new topics in science that were challenging and more detailed than previous years particularly in their early years at secondary school. They talked about science being challenging in a positive and more engaging way. The large number of students talking about curriculum content as a high point of school science experience is an encouraging insight into student perceptions of the current science curriculum. Another aspect of curriculum content that a large number of students talked about is science experiments; there is some evidence to suggest that that students believed doing more and varied science practicals at school made science interesting for them.

In terms of curriculum content as low points of school experience, students talked about being bored by specific topics such as rocks and plants that made them disengage from science. Also, they talked about having to learn too many facts in a rushed manner. However, the main aspect of curricular content that students mentioned as low points was the lack of science experiments particularly in their primary schools. In secondary school, a large minority of students felt that they missed out on doing science experiments because they had supply teachers while another large minority of students felt that experiments decreased in quality and quantity as they progressed through secondary school.

When students talked about teacher influence as high points they revealed that varied activities in the classroom, having a teacher with a good sense of humour and an empathy with their students all increased positive experience of school science. Comparatively, when students talked about teachers in their low points of school experience, they made reference to teachers who never make science fun or interesting; a complaint that was alluded to succinctly by a student who noted *'(the teacher) was so boring; I forgot how interesting science could be'*. Teachers who cannot understand or empathise with students were also a reason for low points. In several student accounts there was evidence that activities such as copying work from the board or from textbooks and excessive videos and power points stopped these students enjoying science. In addition to these points, students talked about effect of classroom environment influencing their low points such as teacher absence, disruptive peers and lack of teacher control. Although this point was not as significant in comparison to the other influences, 42 students felt this issue to have an important impact on their school experiences in the surveys. In the interviews almost a quarter of students talked about these aspects being an important influences on their lack of interest in science.

Perception of science was an important reason for low points in school experience. Students talked about the difficulty of science and its focus on examinations as the reason for their low points; they also talked about how a difficult curriculum had influenced a negative experience of science because they did not feel confident of being successful. They emphasised that lack of science understanding made them less confident; by attaining poor grades they were moved down sets which made them feel quite negative about school science.

8.2.2 Research question 2

To understand the role of school experiences on choice to take science in this sample of students, it is necessary to examine the influences on science decisions for this particular sample of students. This gave rise to the second research question;

> *What are the factors that influence decisions to take science or not in the future?*

The evidence for this research question is provided by the survey questionnaire and the interviews of students. The survey questionnaire contained a number of items about the factors that influence student decisions to take science (see 4.3.1.1) while the interviews provided an in-depth description of the factors that students felt had influenced their decision to take science or not. Quantitative analysis of survey data (see 6.3) and qualitative analysis of interview data (see 4.7.2.1) provide substantial evidence presented in chapter six (section 6.4). The main findings are discussed in the subsections below.

8.2.2.1 Timing of decision to take science

About the time of making decisions to take science or not, for this group of students, the decision to take science or not was mostly made later in secondary school in Year 11 (see fig 6.1). Very few students (5%) in this study had made any firm decisions about taking science or not earlier than secondary school.

8.2.2.2 Influences on decisions to take science or not post-16

From the survey data (table 6.1), a frequency analysis of responses from students who have taken up science at A-level shows that the most significant influences on their decisions to take science are examination results (28%) and curriculum content (23%). A regression analysis of the influences (see table 6.2) also verifies that these are the two most significant influences on take-up of science. These results are confirmed by interview findings (see section 6.4). For these students, curriculum content is an important factor in their decisions to take up science but not as important as exam results.

In terms of the positive influence of the curriculum content on their decision to take science, students talk about different topics that interest them and encourage them to take science further such as astrophysics and organic chemistry. For these students, the science they are interested in is not seen as a difficult subject but one that provides challenges. In contrast, the surveys indicate that the main factor discouraging students from taking science is curriculum content.

For students who have chosen not to take science further, the survey data (see table 6.1) indicates the main influence that impacted their decision was curriculum content (32%) followed by teachers (24%) and then examination results (21%).

The aspects of the curriculum that discouraged students from taking science further were the nature of the topics that students found boring and that made them less interested in science. Some students didn’t like certain aspects of science such as memorising formulae and this puts them off taking science further.

Many students talked about how both teacher pedagogy and personality discouraged them from taking up science (see 6.4.2.2). Teachers who were not fun, inspirational or enthusiastic in their teaching tended to put students off taking science. From the interviews, it was seen that many more students talked about the way teachers discouraged interest in science than those who spoke about the converse – encouragement of interest in science. A distinctive influence of teachers not covered in much detail in current literature were the effects of teacher absence, the negative effects of supply teachers and the inability of teachers to control disruptive behaviour of other pupils.

A number of students talk about their parents influence on their choice of science career and how this has led them to take up science at A-level. Apart from this, some students talk about intrinsic interest in science resulting from television programmes.

It needs to be acknowledged here that there are other influences on the decision to take science and that the lack of emphasis by students of these other influences may have resulted from the focus in the interviews and questionnaires on school-based influences.

8.2.3 Research question 3

Once the influences on students experience of school science and their decisions to take science were known, the main aim of the thesis could be addressed with the help of the third research question;

> *What role does school science experience play in students' decisions to take science or not?*

The answer involved analyses from two main perspectives; one was the quantitative relationship between the ratings from the storyline graphs and student choice of science (see 7.2). The second was an analysis of the qualitative data emerging from the interviews and the survey questionnaires (see 7.3). The main findings are discussed in the subsections below.

8.2.3.1 Student perceptions of school influence on choice of science after GCSE

The survey questionnaire contained an item that asked students whether they thought school had influenced their decision to take science or not. The results (see table 7.3) showed that a majority of students (68%) claim that school experience has had an influence on their choice to take science or not after GCSE. Although this finding does not help explain the role of school science experience on student decisions to take science, it does indicate that students perceive school to have some influence on their future choice of science.

A linear regression analysis exploring students' ratings of science for each of the six years of school science (Years 6-11) indicated that of all the years in secondary school, Year 11 was the most significant for the take-up of science at A-level. From the discussion in 8.2.2.2, it is suggested that many students who are not sure of their career goals or are not confident of their ability in science wait until their GCSE examination results to decide whether to take science or not depending upon their attainment in the exam.

8.2.3.2 Success in science, interest in science and value of science (ISV) as mediators of student decision-making.

Section 7.3 describes how students' experiences of school science are mediated through three main drivers of the decision-making process. These three drivers or factors are success in science, interest in science and value of science (ISV). A model of the mechanisms on students choice to take science or not in the future (see figure 7.4) summarises how the themes emerging from chapters five and six can be represented as a network of influences mediated through ISV. The model is offered as a conceptual framework that supports our understanding of the choice-making process students undertake, but which stresses what might be called the 'rational', criteria-led aspect of the decision-making process.

8.2.3.3 The notion of resilience

Throughout the thesis, the influences on science students' choice to take science and non-scientists' choice not to take science post-16 have been studied, analysed and commented upon specifically in context of school science experience. The majority of scientists were found to have positive experiences of school science while the majority of non-scientists were found to have a less positive experience of school science. However, table 5.1 highlights that a sizeable number of scientists have negative experiences of school science. In section 7.4, the notion of resilience is introduced suggesting that a negative experience of school science can be compensated for by either of the ISV factors. The evidence from student interview data supports the notion of resilience in the case of students, for example Andrew (student profile 7.5.2) who report negative experiences of school science because of curriculum content or teachers; this is compensated for by career goals and success in science.

8.2.4 The storyline graph methodology

The storyline instrument has been used in the literature on college students' feelings of wellbeing (Gergen 1986) and trainee teacher experiences of teaching (Beijaard *et al* 1999) and student teachers development of subject matter knowledge (Nilsson and van Driel 2011). The current study is the first to use a modified version of this method for collecting retrospective longitudinal data from students about their school science experiences. It enabled the collection of longitudinal data without involving the time-scale needed for collecting such data since students were asked to think back over their prior experiences of school science from Year 6 until Year 11. The study contributes an adaptation of existing longitudinal methodology to a quasi-longitudinal approach. This methodology may be criticised by some as being too long a period for students to recall incidents from their school experiences. A possible compromise would be to collect retrospective data over a shorter period of time[67].

In spite of the above limitations of the storyline method, combining this tool with an interview allowed student voice about school science experiences to be heard in rich detail. The time spent in the interviews enabled students to think about and articulate the influences of school and the factors that helped them decide for or against taking science at A-level. The rich detail collected by this method enabled a better understanding of the role of school experience of science on decisions to take science.

8.3 How the study relates to the literature review

Here, the literature review in chapter two is revisited in order to understand how the findings in this study fill some of the gaps in knowledge and how they support or challenge current understanding. Before doing so it is important recall that there are a large set of influences such as social and cultural background and identity that sit separately from the influences researched in the current study and which may inform the findings in this study. However, the aim of the study was to concentrate on the role of school science experience on students' decision-making; therefore the

[67] It is suggested that a period of three years (Years 7 – 9 or 9-11) may be a shorter time-frame for students to recall particular incidents.

contextual background of the study was school science experience and the instruments used were appropriate to that aim.

8.3.1 School influences

The literature review highlighted many aspects of the science curriculum that students had spoken about in other research studies such as the curriculum being exam-driven, content-laden and irrelevant to their lives. However, these views were expressed at a time when science curricula were widely criticised for concentrating on the needs of future scientists rather than a curriculum that would be relevant to all students. The students in the current study have experienced the new science curriculum that was introduced in 2006 but had remarkably similar views about the curriculum being exam-driven and content-laden as those previous to the curriculum change. This corresponds to Osborne and Collins (2001) comment that students are 'frog-marched' through the science curriculum without a chance to absorb what it is they just learnt (p 450). It is discouraging to note that these findings are very similar to the points noted by Osborne and Collins (2001) over a decade ago; there is no change in students' perceptions of the science curriculum and perhaps more importantly, suggesting that there has been no change in the way the curriculum is presented. However, there was little commentary about science being irrelevant to their lives which brings some hope that the new science curriculum may have addressed at least this issue. Also, the perception of science being a difficult subject was reported in the literature and is also a finding in the current study; students view science as a difficult subject that requires concentration and effort to be successful.

An aspect of the science curriculum that is also found in the literature and seemed to be of great significance in student discourse in this study is science experiments. The literature emphasises how science experiments are enjoyed by students and generates short-term engagement (Abrahams 2009). This is corroborated by the students in this study who mention the importance of science experiments as positive school experiences. But it is the role of science experiments in generating interest in science that is a crucial aspect of this study; there is evidence that students who were not involved in science experiments became less interested in science. It is shown (see section 7.3.1) that interest in science is one of the key factors that lead to a decision to take science further. Although science experiments may not directly influence student decisions to take science, they may do so indirectly by affecting student interest in science.

Teacher influence is also highlighted in the literature as a factor that influences students' decisions to take science. Existing literature (e.g. Wai Yung *et al* 2011) points to the characteristics of effective teachers such as enthusiasm, subject knowledge, empathy and teaching style. These characteristics are echoed by the students in the current study; however, the main contribution this study makes is to the literature about ineffective teaching. There is little explicit detail of the characteristics of an ineffective teacher; this study highlights that for students in this sample, teachers who have little empathy for their students, have poor relationships with students and have poor teaching methods are all ineffective teachers. Additionally the students in this study talk about teacher absenteeism and being taught by supply teachers as influencing their interest in science. Another aspect highlighted in this study that does not generate much comment in the literature is the resentment that some students feel when teachers cannot control disruptive students in the classroom. This aspect of classroom environment has an influence not only on student experience of school science but also on their interest in science and in some cases students perceive it has an effect on their success in science.

8.3.2 Individual influences

Above it is already emphasised that there are a number of influences on school experience and student decisions about science that were outside the scope of the current study and therefore did not form part of the questions in the survey. However, there were some influences that emerged from the interviews where students were able to talk about other influences on their decisions. These are detailed below.

Of the individual influences affecting science choice, the most significant one was that of age in relation to decision-making. Studies such as Tai *et al* (2006) find that most scientists and science graduates tended to make science career choices early (before they are 14). The current study finds that most students in this sample make their decisions to take science or not at in Year 11 (aged 15-16). Although this finding contradicts the Tai *et al* study, it is similar to Quinn and Lyon's study that suggests 15-

16 years of age is the time when most students make decisions to take science or not. This is in contrast to Maltese and Tai's (2010) finding that decision-making took place between 11-14 years of age (between Years 7-9).

Additionally in terms of school experience of science; a number of studies (e.g., Bennett and Hogarth 2009) suggest that there is deterioration in interest in science in secondary school. Some suggest (e.g., Jarvis and Pell 2002) that it may be even earlier in primary school. This study finds that science experience for scientists becomes increasingly positive between Years 8-9 while it remains almost the same for non-scientists at a slightly lower positive than scientists. This finding is similar to Lyons and Quinn (2010) who report an increased enjoyment of school science in secondary school. But there is a contrast with other research into attitudes of secondary school students towards school science that reports a decrease in interest from Year 7 that continues into Year 9 (Barmby *et al* 2007) and evidence of an 'age 14 dip'(Bennett and Hogarth 2009). The current findings show that for science students as a whole, experience of school science becomes more positive between Years 8 and 9 while it remains more or less similar to previous years on average for the non-scientists. Although it can be argued that attitudes to science and perceptions of science are two different concepts, Barmby *et al* (2007) view attitudes as a construct of three components closely linked together of which one is 'a feeling about the object; like or dislike component' which is similar to the concept 'perception of science' in the current study. Therefore, it is argued that both studies measure similar concepts and are therefore comparable. An alternative explanation for the mismatch with other research findings is because of a difference in methodology. Both the current study and Lyons and Quinn's (2010) study surveyed retrospective opinions of science while other studies reporting less enjoyment were cross-sectional or longitudinal in design.

Turning now to gender, much of the existing literature on subject preference and subject choice focuses on gender differences. Although this was not the focus of the current study, there were no significant differences in gender experiences of science or decisions to take science or not in the future. The research literature points to males outnumbering females in physics and the reverse in biological studies (e.g., Aschbacher *et al* 2010) but the current study did not find a significant difference in the number of males taking physics or biology compared to females.

The influence of attainment on science choice is documented in the literature (e.g., Vidal Rodeiro 2007) and the current study supports this by providing evidence that exam results are the most significant influence on students' choice to take-up science in the future. There is also additional evidence from student comments about the reasons they choose not to take science despite gaining good grades in science; they feel that they are not good at science and will not be able to bridge the gap between GCSE and A-level. This suggests that influence of actual and perceived attainment in science are both important aspects that impact student choice.

Interest and enjoyment of science is reported by Maltese and Tai (2009) to be the most important reason for science graduates and scientists to have taken up science. This is corroborated by the OFSTED (2010) who report that students choose science mainly because of their interest and enjoyment of science. The analyses of survey and interview data made it quite clear that interest and enjoyment in science were an important part of school science experience as well as in decisions to take science or not further. The important contribution of this study to current understanding of interest in science and its role in science choice is described in section 7.3.1.

8.3.3 Wider social and cultural influences

As discussed in the literature (e.g., Sjaastad 2012), there is little doubt that students are influenced by their relationships and social interactions with important people around them. The literature review emphasises the many ways that families impact on educational outcomes; including the concepts of cultural capital (e.g., Archer e*t al* 2012), socioeconomic status (e.g., Gorard and See 2009), socio-cultural aspects (e.g., Mensah and Kieran 2010) and parental aspirations (e.g., DeWitt *et al* 2012). From student discourse it was clear that parents had an important influence on students' career choice. Some students talk about parental encouragement to choose a science career path and how their parents suggested career paths. Other parents left the decision-making to their children and or supported their children's decisions.

Although the literature points to peer influences on science career choice (e.g., Sjaastad 2012), the students in the current study did not mention this aspect of influence.

8.3.4 Instrumental influences

In the literature, instrumental influences were defined as those that led students to choose science because of science career goals, for admission to science or non-science university courses or for some other extrinsic reward such as praise or accolade from significant others. A number of studies (e.g., Vidal Rodeiro 2007) report that students have a broad view of the utility of science that encompasses the above. However, in this study the students did not demonstrate such a broad view of the utility value of science; instead keeping to the narrower confines of usefulness for their science career goals.

In this study, the group of future scientists made it clear that their future science career goals played a critical role in their decision to take up science. Conversely, a large number of non-scientists suggested that the reason for not taking up science after GCSE was because they did not need science subjects for their career choices. The role of career goals also plays a critical part in student resilience. Together this highlights that career goals are a significant influence on decision-making for the students in this study.

8.3.5 How the study relates to current studies

In the introduction to chapter 3, it was highlighted that during the course of the study several research studies were published which were related to the current study. Of these, several studies are mentioned in chapter 3 and here there is a brief discussion of two other relevant studies emerging from larger projects.

The first is the Targeted Initiative on Science and Mathematics (TISME) which is a programme of research funded by the ESRC[68] aimed to find new ways to encourage children and young people to greater participation, engagement, achievement and understanding of science and mathematics. A number of research projects that are funded as part of TISME help inform the current study. The Enactment and Impact of Science Education Reform (EISER) project examines school responses to the science curriculum reform of GCSE science in 2006. Part of

[68] Economic and Social Research Council

the study focuses on the impact of the reform on science provision at KS4 affecting participation in post-compulsory science courses. Banner, Donnelly, Homer and Ryder (2010) find that the widening range of provision available is leading to a growing polarisation within the provision of science, and potentially on students' take-up of science. They question equitable access to science as a consequence of the increased diversification of routes into taking science. This highlights the influence of school policy on students' choice to take science post-16. Another TISME project; Understanding Participation rates in post-16 Mathematics and Physics (UPMAP) uses a mixture of qualitative and quantitative methods to determine the range of factors and their interactions that influence post-16 participation in mathematics and physics (Mujtaba and Reiss , in press). Their preliminary findings indicate that young people are more likely to continue with mathematics and physics post-16 if they have been encouraged by a key[69] adult; if they believe they will benefit from taking the subject; if they do well in the subject and if they have been taught well at school in the subject. These findings overlap the findings in the current study and support the conclusion.

The second main project that relates to the current study is the Interests and Recruitment in Science (IRIS) project. The project explored young people's educational choice processes and their relationship to STEM finding that educational choice is an on-going process. The respondents[70] to the IRIS questionnaire indicate that interest, self-realisation and passion for the subject have influenced their choice to take STEM subjects (IRIS 2012). They also highlight the importance of interesting and relevant experiences of school science as well as good teachers on their choice to take science. These findings relate to those of the current study by supporting and corroborating the notion of ISV being three important school-experience based factors. However, they also emphasise the importance of identity in educational choice: in order to choose a STEM subject, a student must see themselves as a STEM person.

8.4 Contribution to knowledge

There are two main ways that this thesis has made a contribution to knowledge; firstly, the substantive findings help deepen our understanding of the way students make a choice to take up science or not post-16. The data focus on the extent to which this is a rational choice made by students based on three critical factors – **Interest, Success** and **Value**. It is argued that much of the data collected here support a claim that this process has a strongly 'rational' underpinning the choice to take science or not. Of the three factors, Success is very important

[69] Someone in their family or one of their teachers.
[70] 7000 STEM students in 5 European countries

as it has a dual effect. Firstly, success underpins science enrolment policies in school; if a student is not successful in GCSE science, they are commonly precluded from further study of science post-16. Secondly, success underpins self-efficacy beliefs; if students do not believe they will be successful in science, students will not take up science further despite gaining good grades in GCSE science.

The study also highlights that being successful in science needs to be complemented by either or both of the other two factors; for example, students who are successful in science but are not interested in science or do not have career goals in science will choose not to take science further. On the other hand, students who are successful in science and are interested in science or have a science career goal are more likely to take up science. From student narratives it is seen that after success, students usually take-up science because of their career goals, but seldom if they only have an interest in science; however this final claim needs to be supported by further evidence.

The conceptual framework identified here also encompasses an understanding of why some students are not put off science by disruptive pupils or absent or inadequate teachers while others are put off. This quality within the process has been captured through the notion of **resilience**. Students whose narratives demonstrate elements of resilience display a certain degree of autonomy over their learning through ISV. These students remain successful at science and retain their interest in science subjects despite negative experiences of school science. Conversely, the narratives of students with positive experiences of school science emphasise how lack of success or lack of science career goals are the main reasons for their choice not to take science.

The second contribution to knowledge made by this study is methodological. The current study used an adaptation of the **Storyline** method to collect data from students about their school science experiences. This methodology can be called a 'quasi-longitudinal' method as it enabled the collection of longitudinal data without involving the time-scale needed for collecting such data since students were asked to think back over their prior experiences of school science from Year 6 until Year 11; effectively collecting six years' longitudinal data.

The interviews allowed student voice about school science experiences to be heard. The time spent in the interviews enabled students to think about and articulate the influences of school and the factors that helped them decide for or against taking science at A-level. The rich detail collected by this method enabled a better understanding of the influences that shaped both school experience of science and decisions to take science. So the final contribution which the study can claim to have made is an enhanced and systematic attention to the **Student Voice**.

8.5 Evaluation of the study

Having pointed out the contributions that this study makes to the research field in the section above, it is important to add a note of caution applied to the current findings; firstly, they are a snapshot of the opinion of a small sample of students that completed the survey questionnaires. Secondly, it is a retrospective study into student opinions of science and it is acknowledged that students' opinions may have changed over the years and that they are not fixed or final. In addition the limitations of the study must also be taken into account.

The study was limited in two main ways; both concerning research methodology. The first limitation arises from the nature of carrying out research in schools where a researcher is dictated by the schools' priorities and calendars; leaving little time to analyse data and modify interview questions accordingly. By the time interview data was transcribed and analysed, the interview phase was over with no time or resources left to re-interview.

Firstly, the survey and interview data in the second phase did not give a complete picture of the influences on school experiences of science. Although it was planned to carry out the interviews systematically with gaps between to allow transcription and analysis, the rescheduling of interview times to suit the schools' calendars meant that they had to be carried out in a short interval of time with no gaps in between. Most of the interview data was transcribed and analysed together and it was not until the latter stages of analysing the findings that it became apparent that questions about school experiences of science should have been structured in a way that its influence in decisions to take science could be probed in detail. I suggest here that one way to collect the requisite detail is to rephrase the existing question '*do you think school has influenced your decision to take science?'* to *'do you think your experience of school science has influenced your decision to take science?'* and link it with another question '*what is it about your school experience that has influenced your decision to take science?'* Similarly the inclusion of this question in the schedule for the semi-structured interviews would prompt students to think about this aspect. The data collected from both interviews and surveys for these questions would enable a clearer picture relationship to be established between experience of school science and decision to take science and perhaps more conclusive evidence to emerge.

However, it is also acknowledged that analysis of the data to inform further interviews would cause two potential problems, 1) the interview questions would change and this would introduce variability between responses from an earlier sample of students and a later sample and 2) the emergence of relationships from early analysis may introduce a bias in the researcher's questions. Similarly, it was difficult to fully understand the role of school science experience on the value of science in decisions to take science. Asking students about the factors that influenced their career choice could have been useful in examining the role of schools careers services as well as the role of teachers in students' choice of science or non-science careers in more detail.

Secondly, it is suggested that the nature of the instruments used can cause a different emphases in the findings. For example, the interviews were able to probe a deeper explanation of influences while the survey presented a choice of either yes or no without the opportunity to explain the reasons behind the influences. The interview prompts gave students a chance to think about the factors that influenced their decisions in a more profound way and that the time spent deliberating and talking about their answers may have revealed aspects that they had not thought about before. For example, when talking about the effect of school influence on their decision to take science, students realised that specific factors such as lack of science experiments were the reason for their decision not to take science and they were able to articulate this in more detail rather than just saying school influenced their decision not to take science. Lyons (personal communication) finds a similar dissonance between findings from data collected using different methodologies. Another methodology-related question arises about the suitability of retrospective data collection to studies of student decisions.

Finally it is also important to note that the major limitation of a study of this type lays in the difficulty of disentangling all the influences and indeed the dynamics of student decision-making. Because of a focus on school influences, it was not possible to examine other potential influences (notably things like identity) and their possible interaction with school influences.

What *has* been achieved in this study is the intensive focus on the school experience and the decision-making process which was perceived to be a gap in the literature.

8.6 Implications & recommendations

The school science experiences portrayed by the students suggest that the quality of the learning experience needs to be improved so that interest in science is increased and students want to take-up science as an interesting subject even if it is not needed for their career goals. In particular there is a need for the science curriculum to be more engaging and less repetitious. The introduction of a new science curriculum deemed to be more engaging and relevant to students' lives was heralded as the answer to the calls for a curriculum change in the previous decades. There is yet to be a full evaluation of the success of this new curriculum but student comments indicate that to them, the current science topics are boring, full of theory and exam-focused; similar to comments made by students almost two decades ago. However, without a full evaluation of the new curriculum, it cannot be claimed that the curriculum is at fault. What may be the case is that pedagogy has not followed the curriculum change; evidenced by a number of comments made about transmissive pedagogies by the students in their interviews.

The most positive learning experiences of many students in this study transpired where students perceived their teachers being enthusiastic and inspiring as well as having good teaching practice. This leads to the recommendation that science teachers not just consider the subject content as important but the way in which that subject content is taught. A large minority of students feel that their science teachers rely too much on ICT led lessons (power points and videos).There is a preference among this group of students for student-centred approaches and less 'chalk and talk'. However, the greatest influence on interest in science is science experiments. Students 'expect' science lessons to involve some experimental work; in classes where regular practical work is included in the repertoire of teaching approaches, students report an increased interest in science.

Related to teaching practice; negative experiences of school science occur where there is greater teacher turnover and frequent teacher absence. It is recommended that science departments reflect on their policy of allocating supply teachers[71] to make sure that early experience of school science is not marred by teacher absence or frequent changes of supply teachers. However, it is also important to note that older students are also affected negatively by teacher turnover and therefore it is necessary to have a pool of well-qualified science teachers who can be called upon to fill in a temporary gap in the science department.

Science curriculum teaching needs to be spread evenly throughout the academic year to avoid students feeling overloaded at stress points especially near examination time. The practice of early introduction of GCSE science – as early as Year 8 in some schools – also needs to be addressed. Too early an introduction to the science GCSE course leads to students feeling overburdened with difficult and exam-focused science topics. This leads to the perception of science being difficult and has implications both for interest in science as well as success in science. A recommendation is that students are introduced to GCSE science in the latter half of year 9 after a thorough grounding in basic science concepts in the preceding years. These basic concepts should be taught creatively and enthusiastically by well-trained teachers who are able to enthuse and inspire their young and impressionable students.

Finally, having a career goal in science is a focus that keeps students interested in the subjects they take post-16. Teaching science in a way that makes students aware of the potential of further study of science will contribute to informed choice. Cleaves (2005) in her thesis finds that the limited image of a working scientist is a factor in students opting not to take science further.

A note-worthy absence from the interviews of the students in the current study is the reference to the role of school careers advisory services (Connexions)[72] or indeed any careers guidance provided by the schools. It may be that these students benefitted

[71] Some science departments assign temporary or supply teachers to the KS3 years in the case of long-term absence of the regular teacher so that the examination classes in KS4 are not affected.
[72] It is noted in Chapter 4 that several of the schools where students were interviewed had this service available for all students in Year 9 onwards.

from careers guidance either formally through the service or informally by teachers but did not associate this as a school influence; however it is perturbing to find that none of the 53 students mentioned any careers guidance from the school.

With the disbanding of Connexions by the previous government and in the absence of a regulated careers advisory service[73] for young people, it is important that schools provide careers guidance to their students either through a whole-school approach or through individual basis in PSHE lessons. Cleaves (2005) points out that careers guidance impacts students choice in diverse ways and that the usefulness and effectiveness of school support are related to different ways that students approach career choices. Thus, careers guidance is a responsibility that cannot be delegated to teachers without providing adequate understanding and training; teachers opting to take up careers advisory posts should be properly trained and given due recognition for this.

8.7 Further work

The first suggestion for further work is to explore further the issues raised by this study. Investigations could be undertaken to examine the transferability of these results to a wider population of students from different schools. Such research could seek to avoid the limitations of the study and look at other methods to explore the relationship between school experience of science and decision to take science. There could also be a focus on how students decide their career goals. For example, interview schedules could be developed to include prompts or questions about these aspects and the survey questionnaires could be adapted in the way mentioned above.

Further work is also needed to establish how comprehensive and inclusive the suggested framework is and how social background variables interact with the key factors; success, interest and value of science. A suggestion is to examine how identity and SES feed into the rational model of decision-making examined in 7.3 above.

[73] The current government has set up a publicly funded National Careers Service to bring together elements of careers services for young people. Although ostensibly for young people aged 13 or over, the agency only provides website and phone advice to young people aged over 18 with no face-to-face contact.

The storyline method has been found to be a useful tool to gather both qualitative and quantitative data. Future research could involve using this tool in the way that it was originally proposed by Gergen (1986); in interviews, students are asked to complete the storyline graphs and talk about the high and low points as they draw their graph. These points can then be used as the basis for further questioning in the interview.

The current findings indicate that further investigation is needed into the significant time to make science choices perhaps in the form of a cross-sectional or longitudinal study to investigate which year(s) in secondary school are important in decision-making[74].

8.8 Concluding remarks

In 2001, Osborne and Collins expressed concern that science is seen as a subject of little interest and a domain that is exclusive and beyond the comprehension of the average individual leading to a rejection of the subject. More than twelve years later and after a number of curriculum changes brought in by successive governments, the situation with student enrolment numbers in science has improved only slightly.

This study argues that students usually choose to take science if they are interested, successful and value science; students who are successful but choosing not to take science do so because they are not interested in it nor does it hold value for them. It suggests that interest, success and value of science were influenced in significant ways by school experiences of science. To improve science take-up, schools can and should change current practices to improve school science experiences for students to help increase interest, success and value of science.

The central contribution that this thesis offers is in suggesting a conceptual framework to help understand how students arrive at a decision to take science further. The three factors - ISV - help mediate how school science experience informs the decision to take science or not in the future. It is suggested that school science experience is seen as a site for intervention to increase take-up of science post-16.

[74] Although longitudinal studies are better in controlling for individual student differences, a cross sectional study have the advantage of being less time and resource consuming. Data about science choices can be collected concurrently from students in Year 7 – 13 to investigate the pattern of choice-making between students in each year.

The final word on this matter goes to a student (C12 FSP) who sums up how her experience of school science influenced her decision to take science at A-levels:

> *For me personally it was here we go another science lesson, just couldn't wait to get through it. But by the end…I really got interested in it; over the years the methods they used and the varied practicals became more interesting and that really changed my mind to take science.*

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Appendix A

Original interview schedule

Interviewer	**Student**
Your graph is very interesting, I wanted to ask you about (refer to all the points on graph). Can you explain the reason for putting these points here?	
Would you say that your interest was the same for all three sciences throughout secondary school?	
What would you say was the most significant influence of school science on your subject choice?	
What school factor do you think would influence you to take science?	
What are your future plans?	
What will make you carry on with X subject after A-levels?	
Is it the same for you with other subjects ?	

Appendix B

Interview schedule – final

I'm interested in your view of school science and I want to find out how you decided about you're a-level / BTEC subjects. There are no right or wrong answers; I'd just like to hear you opinion of what made you choose your subjects.

Q1. In your opinion, what is the value of science?

a. What do you think is meant by school science?

b. First of all could you tell me how you came to choose the subjects you have now?

Q2 Now that you've studied them for six months, would you change anything?

Q3. Did you enjoy school science – what aspects? Which particular years?

Q4 How did school science make you feel about taking up science in the future? Do you think it had an influence on your later choice to take science?

Q5 Did you feel the same way about all three sciences?

Q6 Your graph is very interesting - can you explain what events you were thinking of when putting these points here?

Q7 What was your attitude to science when you started school…what was it by the end of Year 11?

Appendix C

Original survey questionnaire

Name ....   Gender: FEMALE / MALE

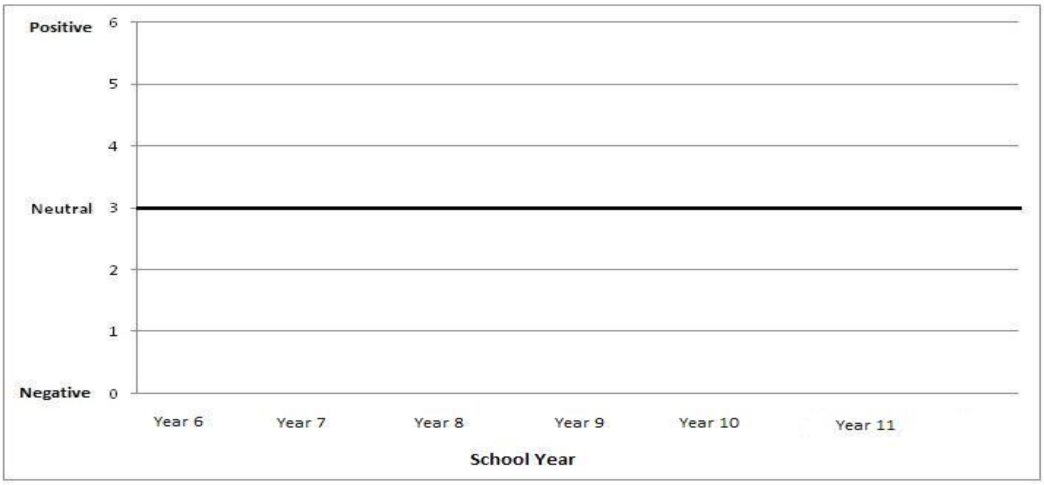
A level subjects (put a circle around the one you want to drop):

....

What course do you want to do at university? Circle one: SCIENCE / NON-SCIENCE   / NOT SURE

On the graph below, draw a point for each school year to indicate what you felt about school science in that year. For each point you've drawn, write down one factor that influenced your decision at that point in the comment box below the graph.

What was your opinion of science at school?



School Year	Comment	Did you want to take science in future?
Year 6		
Year 7		
Year 8		
Year 9		
Year 10		
Year 11		

When do you think you came to a definite view about whether to take science or not?................

Did your experience of science at school influence your decision to whether to take science or not?

YES   /   NO

What was the main reason in or out of school that made you decide whether to take science or not?

....

END OF QUESTIONNAIRE - THANK YOU

Appendix D

Final survey questionnaire

Name ....Gender: FEMALE / MALE

Write down the A level / BTEC subjects that you are taking at the moment and circle any science subjects:

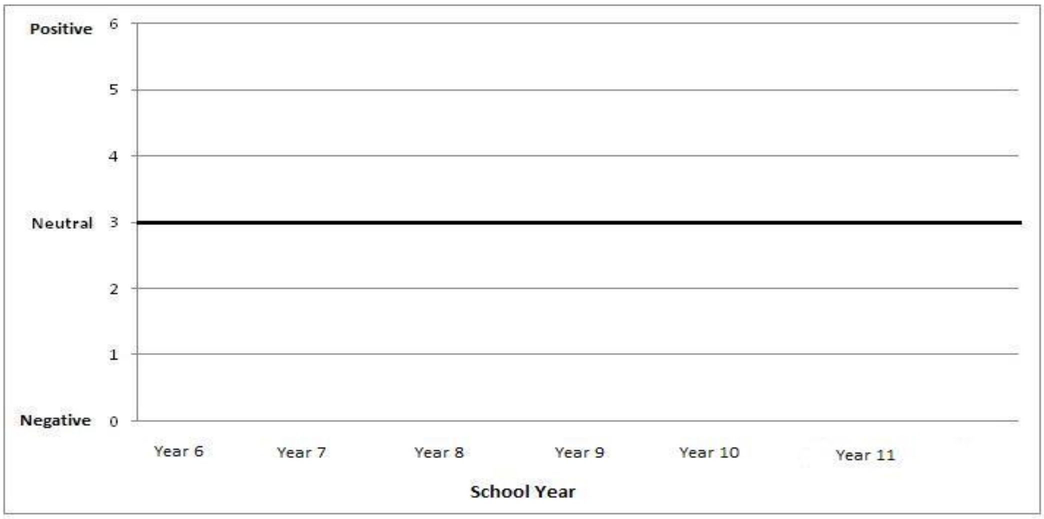
....

....

Do you plan to take science at university? YES / NO / DON'T KNOW

1a. On the graph below, draw a point for each school year to indicate how you felt about school science in that year.

What was your opinion of science at school?



b. Explain the reasons behind your high and low points in the spaces provided. If there are no high or low points, choose any two points and explain your opinion of school science at that point.

Low point(s)..

....

High point(s)...

....

2. When did you make a firm decision to take science /not to take science in future?..

....

3. Do you think school science has influenced your choice whether to take science or not in the future? YES / NO

If you said YES above, then go to Q4.

If you said NO above, then explain what influenced your decision about taking science or not..

....

4. In the table below are some school factors that have influenced other students in their decision whether or not to take science.
Tick the boxes that you think have influenced your decision.

	This influenced me *not* to take science			This influenced me to take science		
	A lot	Some	A little	A lot	Some	A little
The teacher	☐	☐	☐	☐	☐	☐
The way science is taught	☐	☐	☐	☐	☐	☐
Science topics that were taught	☐	☐	☐	☐	☐	☐
The subject options allowed by the school	☐	☐	☐	☐	☐	☐
Careers advice you were given	☐	☐	☐	☐	☐	☐
Exam results in science	☐	☐	☐	☐	☐	☐
Other school factor (please explain)						

Now circle the ONE that had the biggest influence on your decision to take science or not.

Is this influence the same for all three sciences? YES / NO

If no, then explain the difference below:

Appendix E

Content analysis of survey data

An adaptation of Willms and Johnson's (1996) content analysis of survey data:

1. Sample 20 survey questionnaires to see what students have written about their high and low points.
2. Make rough categories and code with a keyword (eg interest)
3. Check next batch of 20 scripts.
4. Revise codes
5. Check with another batch of 100 scripts
6. Add/ change categories if necessary
7. Carry on checking with batches of 20 scripts until saturation
8. Interpret coding list to end up with a number of meaningful categories (5-7)
9. Make a final list of themes by collapsing the coding categories

Content analysis codes and themes

Rough categories	Coding categories	Themes (collapsed categories)
High points: Interest Enjoyable Practicals Complex Challenging New topics Exciting topics Liked topics Good topics Less exam focus Good grades Liked teacher **Low points:** Boring Didn't like Didn't enjoy Topics not interesting No practicals Too much focus on exams Too much theory Not good at it Low grades Hard Difficult Didn't like teacher Didn't like teaching Supply teachers	Content Teaching Difficulty Attainment School agency Interest Disruption Teacher absence Practicals	Teachers / teaching Curriculum content Perception of science Attainment Interest / enjoyment Classroom environment

Appendix F

Qualitative analysis of interview data

The following procedure was used for inductive analysis of qualitative data (Thomas 2003).

1. Data cleaning - Format the raw data files in a common format

2. Close reading of text - raw text read in detail to become familiar with the content and gain an understanding of the details in the text.

3. Creation of categories - Identify and define categories. Categories are created from actual phrases used in specific text segments. Use NVIVO to speed up the coding process.

4. The rest of the scripts are coded - segments of text may be coded into more than one category.

5. Revision and refinement of category system - the categories may be combined or linked under a theme when the meanings are similar.

Categories emerging from the data and the resultant themes:

Initial categories	**School science experience themes**	**Decisions to take science themes**
• Career • Change in career choice • Needed for university		Career goals
• interest • enjoyment	Interest / enjoyment	Other influences (interest)
• science topics	Curriculum content	Curriculum content
• practicals	Curriculum content	Curriculum content
• science was simple / easy • difficulty of science • confusing	Perceptions of science	Perceptions of science
• grades • success	Attainment	Attainment
• disruption • parental influence • TV	Classroom environment (disruption)	Other influences (parents and interest)
• Teacher personality • Teacher pedagogy	Teachers	Teacher influence

Exemplar transcript – R6 MNC

I: So first of all, what I want you to do is, explain to me why you made these choices for A level?

S: Well firstly history, since I was young I have found history intriguing, why some people or some dictators do stuff and stuff like that, economics was one I had to choose on the spot, it was either that or psychology, and I thought that maths and economics go well together and maths and English I've always been good at since I was really young, I enjoy reading books.

I: I noticed from your graph that it going downwards, as you progress through secondary school, do you want to talk me through these different years?

S: Well year 6 and year 7 was obviously from SATs in year 6 I got the highest grade possible which was a 5 and it kind of went down from year 8 to year 9, it just started to get a lot more intense and that's when I figured out that science isn't really my thing.

I: What about year 8, you sort of had a real drop in opinion there?

S: Year 8 was probably.... that's when probably physics and chemistry, and that's when we started to look at atoms and particles and I just really didn't like it.

I: How did you do in science?

S: I got a B overall

I: So that's not bad?

S: Yeah it could have been better

I: OK, tell me about things; out of all these year which was your best year, sort of when you were most excited about science?

S: Year 6

I: So you came into secondary school being really excited about science and you have got a really high opinion of it in year 7 tell me a little about what you found; you were really excited about going to secondary school, what did you find here?

S: I didn't come to this school, basically from year 6 that momentum carried on to year 7, I was confident about it in year 7 but obviously in year 8 it started to get more intense.

I: Do you mean it got harder?

S: Yeah it got a bit harder

I: So expectations changed; what were you thinking?

S: I mainly got the idea not to take science from college, which was roughly around year 11, there were other subject that were more appealing.

I: What do you want to do with this combination of subjects? Have you thought what you want to do?

S: As I said before that economics and maths go well but the main route I was going to take was to take the history degree at university and then take a two year law course.

I: Tell me about history, you said you were interested in it, how far back can you remember being interested in history?

S: Since I was really young, about 10 or 11, just from reading books

I: What about your family or friends, how many historians or what type of encouragement have you had from them?

S: Well mostly my cousins and uncles have all been down the science route like becoming doctors and pharmacist, like my dad is a pharmacist, me and my dad used to talk about history so that was kind of a big impact on.

I: Did your dad tell you to take science?

S: Yeah they encouraged it, both my mum and my dad but I knew that I never liked it.
I: Do they support you to do history?
S: Yeah
I: So I wanted to know about the low points, which year would you say was the low point for you?
S: Probably year 10 or year 11
I: Why is that?
S: It really started to get intense; it got really hard and the amount of work I had to put in was kind of going over my other subjects. I could have got an A if I single-mindedly thought about science; but other subjects and the amount of work you have to do, remembering formulas.
I: OK, you said that school science didn't influence your choice about whether to take science or not in the future, when you say external advice made you not take science, what do you mean by external advice?
S: Basically my cousins went to university doing science, doing biology, whenever I go see them and I see the amount of work they have to do for science.
I: That put you off?
S: Yeah. I already know that science isn't my stronger subject, so I knew for a fact that I wasn't going to get the highest grade possible for science.
I: So you're saying that you may go on to do history or you may go on to do economics, so does that depend on what grade you get?
S: Yeah but I am thinking of dropping economics this year
I: And what will influence that choice?
S: That is just because that is the least achievement I am going to get.
I: So you may drop economics, but you will take history maths and English forward, what do you think you would like to study at university?
S: Archaeological history
I: Would you be the first in your family to do that?
S: Yeah
I: And how does that make you feel?
S: Proud in one sense but its unique basically... it's a unique feeling cause everyone has done multimedia history like my brother and everyone has done science.
END OF INTERVIEW.

How the transcript was coded

Int: So you came into secondary school being really excited about science and you have got a really high opinion of it in year 7 tell me a little about what you found; you were really excited about going to secondary school, what did you find here?

S: I didn't come to this school, basically from year 6 that momentum carried on to year 7, I was confident about it in year 7 but obviously in year 8 it started to get more intense.

Time of decision

Perception

Perception

I: Do you mean it got harder?

S: Yeah it got a bit harder

I: So expectations changed; what were you thinking?

S: I mainly got the idea not to take science from college, which was roughly around year 11, there were other subject that were more appealing.

I: What do you want to do with this combination of subjects? Have you thought what you want to do?

Interest

S: As I said before that economics and maths go well but the main route I was going to take was to take the history degree at university and then take a two year law course.

I: Tell me about history, you said you were interested in it, how far back can you remember being interested in history?

S: Since I was really young, about 10 or 11, just from reading books

I: What about your family or friends, how many historians or what type of encouragement have you had from them?

S: Well mostly my cousins and uncles have all been down the science route like becoming doctors and pharmacist, like my dad is a pharmacist, me and my dad used to talk about history so that was kind of a big impact on.

Value

Parental influence

I: Did your dad tell you to take science?

S: Yeah they encouraged it, both my mum and my dad but I knew that I never liked it.

Family influence

I: Do they support you to do history?

S: Yeah

Interest

I: So I wanted to know about the low points, which year would you say was the low point for you?

S: Probably year 10 or year 11

I: Why is that?

S: It really started to get intense; it got really hard and the amount of work I had to put in was kind of going over my other subjects. I could have got an A if I single-mindedly thought about science; but other subjects and the amount of work you have to do, remembering formulas.

Difficult

, you said that school science didn't influence your choice about whether to take science or not in the future, when you say external advice made you not take science, what do you mean by external advice?

Curriculum content

S: Basically my cousins went to university doing science, doing biology, whenever I go see them and I see the amount of work they have to do for science.

Content

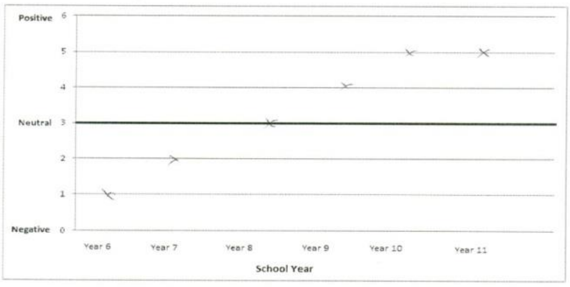
I: That put you off?

S: Yeah. I already know that science isn't my stronger subject, so I knew for a fact that I wasn't going to get the highest grade possible for science.

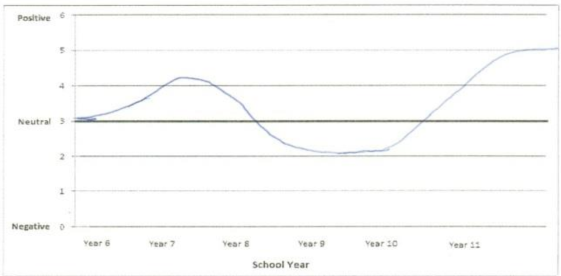
Lack of success

Appendix G

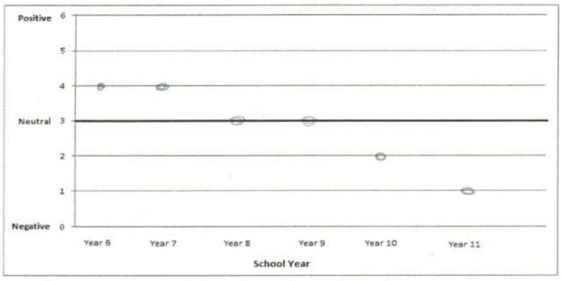
Types of storyline graphs



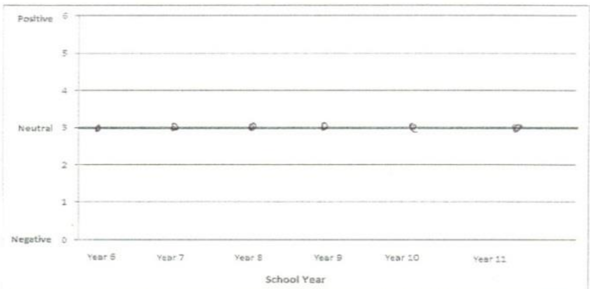
No 1: A progressive (P) storyline – this indicates a generally positive experience (C1 MNC)



No 2: a PUD storyline – this indicates an unstable experience fluctuating between positive and negative points (C2 MSF)



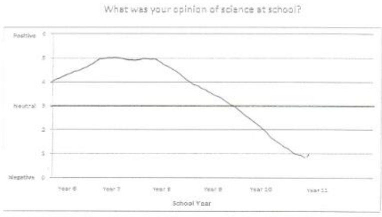
No 3: a regressive (R) storyline – this indicates a generally negative experience (R9 FNE)



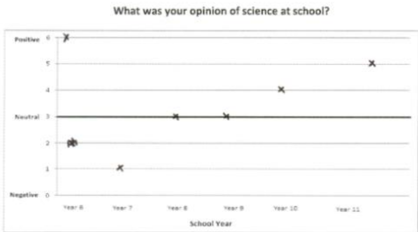
No 4: A stable (S) storyline – this indicates a relatively stable experience (C4 MNE)

Appendix H

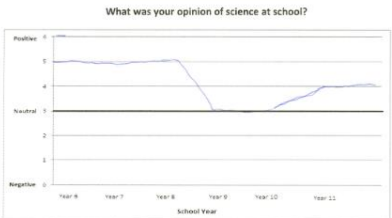
Examples of decisions taken to collapse trajectory types



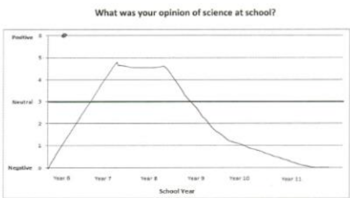
Graph C5 MNS: This graph was classified as a regressive trajectory despite the early progressive trajectory because it ends lower than it started.



Graph C13 FSP: This graph was classified as a PUD as the storyline becomes progressively positive although there is an initial dip in Year 7.



Graph C9 MSF: This graph is classified as PUD since there is a dip at Years 9 and 10; although the student starts off on a higher positive he still has a high positive in Year 11.



Graph R11 FNS: This graph is classified as regressive although it has a period of positive experience between Years 7 to 9. However it ends at a low point and this is the reason it is classed as a regressive graph.

Appendix I

X^2 test of significance between scientists and non-scientists per trajectory types

Trajectory	Observed		Expected		X^2	Is there a difference?
	Science	Non-science	Science	Non-science		
PC	122	77	95	104	0.000151006	Sig
PUD	62	56	57	62	0.311423552	None
S	29	45	35	39	0.13417967	None
R	59	118	85	92	0.000106176	Sig

Appendix J

X^2 test of significance between scientists and non-scientists for each stable trajectory type

Stable trajectory	Observed		Expected		X^2	Is there a difference?
	Science	Non-science	Science	Non-science		
High	20	17	14.5	22.5	0.063997	none
Low	1	12	5.09	7.91	0.020003	sig
Neutral	8	16	9.41	14.59	0.556764	none

Appendix K

The difference between the perceptions of scientists and non-scientists for each year at 95%CI

	Scientists (n=290)	SD	SE	95%CI	95%CI	Non scientists (n=279)	SD	SE	95%CI	
Year 6	3.7	1.5	0.08	3.86	3.54	3.3	1.6	0.1	3.50	3.10
Year 7	3.7	1.3	0.08	3.86	3.54	3.3	1.5	0.09	3.48	3.12
Year 8	3.7	1.3	0.07	3.84	3.56	3.2	1.4	0.09	3.38	3.02
Year 9	3.8	1.4	0.08	3.96	3.64	3.1	1.3	0.08	3.26	2.94
Year 10	4	1.6	0.09	4.18	3.82	3.1	1.4	0.08	3.26	2.94
Year 11	4.6	1.7	0.1	4.80	4.40	3.1	1.3	0.08	3.26	2.94

Appendix L

Chi squared test of significance of factors influencing choice to take up science

OBSERVED	Most influence	Some influence	A little influence	total	%
Exam results	122	75	38	235	0.178436
Science topics	104	87	33	224	0.170084
Options allowed	57	88	80	225	0.170843
Teacher	56	110	52	218	0.165528
Careers advice	53	59	85	197	0.149582
Way science is taught	49	111	58	218	0.165528
total	441	530	346	1317	

EXPECTED	most influence	some	little	X^2	difference
Exam results	78.69021	94.57099	61.7388	9.17E-09	None
Science topics	75.00683	90.14427	58.8489	1.19E-05	None
Options allowed	75.34169	90.5467	59.11162	0.002582	Sig
Teacher	72.99772	87.72969	57.27259	0.00642	Sig
Careers advice	65.96583	79.27866	51.7555	4.82E-07	None
Way science is taught	72.99772	87.72969	57.27259	0.00088	Sig

Appendix M

Chi squared test of significance of factors influencing choice not to take up science

OBSERVED	Most influence	Some influence	A little influence	total	%
Science topics	64	78	56	198	0.163232
Exam results	61	76	103	240	0.197857
Teacher	49	69	76	194	0.159934
Options allowed	42	62	87	191	0.157461
Way science is taught	36	93	71	200	0.16488
Careers advice	32	51	107	190	0.156636
total	284	429	500	1213	
EXPECTED	most	some	little	X^2	difference
Science topics	46.35779	70.02638	81.61583	0.000397	Sig
Exam results	56.19126	84.88046	98.92828	0.470432	None
Teacher	45.42127	68.61171	79.96702	0.78625	None
Options allowed	44.71888	67.5507	78.73042	0.474729	None
Way science is taught	46.82605	70.73372	82.44023	0.003888	Sig
Careers advice	44.48475	67.19703	78.31822	0.000129	Sig

Appendix N

A-level entries by subject 1996 - 2012

Source: DfE (2013) Statistical First Release: Additional tables 3

Table 10: GCE A level results of students aged 16 to 18 by subject, grade and gender

Years: 1995/96 to 2011/12 (revised)

Year	Biology	Physics	Chemistry	Maths	All subjects
1996	43398	28400	34677	54125	620,164
1997	47598	28777	36429	56050	662,163
1998	48897	29672	37103	56589	681,082
1999	47192	29552	35831	56100	680,048
2000	46190	28191	35290	53674	672,362
2001	44592	28031	33871	54157	681,553
2002	45407	27860	32324	44156	645,033
2003	43902	26278	31065	44453	662,670
2004	44235	24606	32130	46017	675,924
2005	45662	24094	33164	46034	691,371
2006	46624	23657	34534	49805	715,203
2007	46797	23887	35077	53331	718,756
2008	48397	24703	36328	57618	741,356
2009	47978	25620	37141	64517	757,696
2010	52728	27786	40379	69803	783,347
2011	54738	29205	43249	75546	782,771
2012	55817	30750	44729	78078	779,483

Appendix O

Statistical analyses

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.440[a]	.194	.185	.8720

a. Predictors: (Constant), Yr_11_11, Yr_6_6, Yr_8_8, Yr_9_9, Yr_7_7, Yr_10_10

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	102.467	6	17.078	22.460	.000[b]
	Residual	425.801	560	.760		
	Total	528.268	566			

a. Dependent Variable: science_Alevels_SCI

b. Predictors: (Constant), Yr_11_11, Yr_6_6, Yr_8_8, Yr_9_9, Yr_7_7, Yr_10_10

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.395	.134		-2.951	.003
	Yr_6_6	.044	.030	.071	1.475	.141
	Yr_7_7	-.004	.042	-.006	-.097	.923
	Yr_8_8	.024	.046	.034	.526	.599
	Yr_9_9	.057	.041	.080	1.379	.168
	Yr_10_10	-.040	.039	-.064	-1.026	.305
	Yr_11_11	.239	.031	.432	7.756	.000

Appendix P

Coding for ISV factors

Students' interview transcripts were read and text units were marked for each ISV factor. The student comments were noted down in a similar table to the one below (one table for each of the four student types). The comments are not verbatim records but my own notes of the students' comments relating to each of the ISV factors. Some transcripts did not yield any comment about success, value and interest in which case the relevant section was left blank. Where students' comments indicated they were interested, successful or held value for science, the relevant notes were highlighted.

The following is an example of the group of potential scientists' comments.

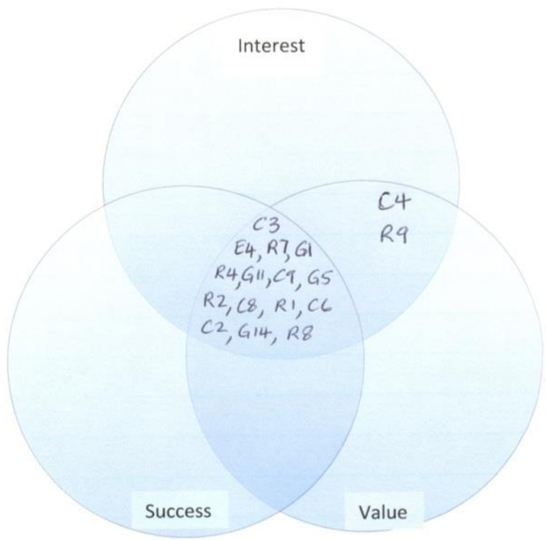
Student	Interest	Success	Value
C13	*Interested in photography and science*	*Exams didn't go well – not confident in science*	*Doing science to prove I can do it*
G10	*Science is interesting*	*Good at science in GCSE*	-
G15	*Physics is interesting*	*Always good at physics*	*Won't do science at university*
C12	*Interested in science*	*Don't do well in exams*	*Forensic science*
E10	*Going to drop biology at A2 / not interested*	*All A's in science*	*Plans to do law*
G7	*Interested in science but don't like physics*	*Stronger in biology than the other two*	*Plans to go into midwifery*
E9	*Dropping biology at A2 but carrying on with physics*	*Took triple (science); did well*	*Doing maths at university*
E7	*Not really interested in science*	*Could be doing better*	*Took biology as a fourth subject*
E5	*Interested in science*	*Struggling*	*Biology was a wild card*
E3	*Biology is my favourite subject*	*Challenging; will drop biology*	*Doing a maths degree at university*

The highlighted comments were then used to draw up Venn diagrams for ISV factors. In the example above, C13 is drawn at the intersection of Interest and Value. G10 is drawn at the intersection between Interest and Success and so on.

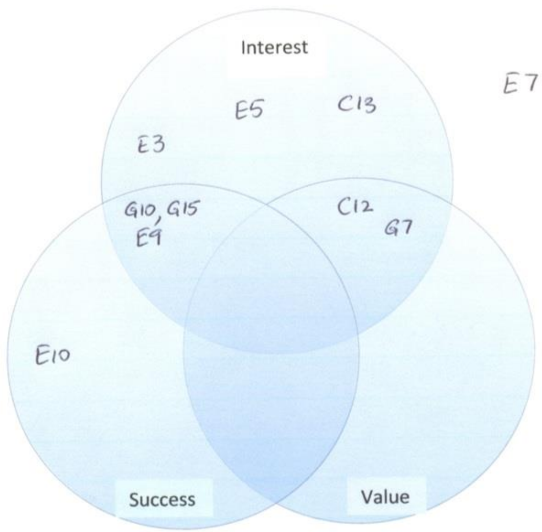
Student types and ISV factors

Each student is added into the Venn diagram according to the comments made (see table above) for each type of student. Students making no comments about ISV factors i.e., those that indicate no interest in science, they are not successful in science and they do not have career goals in science are represented on the outside of the Venn diagrams.

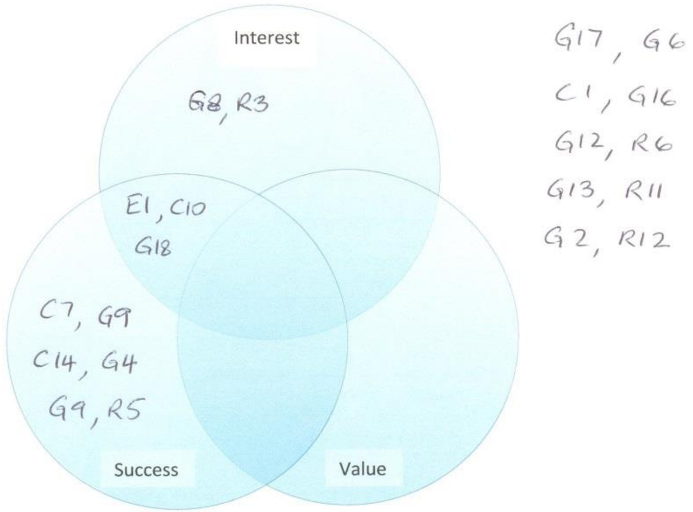
Future scientists



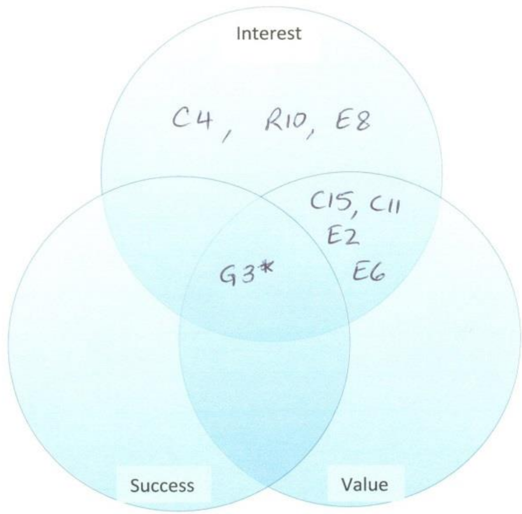
Potential scientists



Non-scientists by choice



Non-scientists by exclusion



*this student is an exceptional case; he wasn't allowed to take science at A-level because of his previous disruptive behaviour in science lessons – in effect he was excluded from science but not because of lack of success, interest or value.