Girls and A level Physics: Identity and Choices

Amelia Deborah Maud Thorley

A thesis submitted in partial fulfilment of the requirements of
Sheffield Hallam University
for the degree of Doctor of Philosophy

July 2014

Abstract

This thesis addresses the question of how physics identity and physics self efficacy influence girls' choices to study or not to study physics post-16. This question is important because only 20% of the overall 16-18 physics cohort in England and Wales is female.

A theoretical framework for physics identity is proposed using socio-cultural theories. An extensive review of the current literature on the issue of girls in physics, physics identity and physics self efficacy was used to support this framework.

A mixed methods methodology with a funnelling approach to selecting participants was used. Two schools were selected because they had in the past demonstrated a higher than average progression rate for girls onto post-16 physics. An initial questionnaire was completed by 458 14 and 15 year old pupils. From the answers given on the questionnaire, 43 girls were selected to participate in three rounds of small group interviews. These girls were ones who were both thinking of studying physics post-16 and those who were not. Finally, extended narratives of four girls were developed to illustrate the links between physics identity, physics self efficacy and physics choice.

Descriptive analysis of the questionnaire data was used to give a background picture of the pupils' overall views about science and physics, science and physics teachers and lessons and how they felt about physics. The group interview data was analysed thematically drawing on the themes identified in the literature review and themes that emerged from the data. The stories of four girls were analysed using narrative methodology.

The results show that the issues of girls' engagement in physics cannot be resolved unless a holistic view is taken; that developing identification with physics occurs within the wider identity development of the girls that takes place in the many figured worlds that they inhabit. Particular notice needs to be taken of how girls' identification with physics develops due to interactions with teachers; how physics plays a part in the discourse of achievement and how society in general influences this identification. The research showed that there was little difference between future choosers and non choosers of physics.

Acknowledgements

I would like to take this opportunity of expressing my thanks to all those people who have helped me in any way to complete this thesis.

Firstly I would like to thank the management and teaching staff of the two schools who agreed to support my work by allowing me to interview their students. A massive thank you to the girls from both schools who came to talk to me and shared their experiences of physics with me. Without them, there would not be a thesis.

My sincere thanks to Prof. Hilary Povey and Dr Mark Boylan for their productive comments throughout the time I have been working on this project and their constructive feedback on the writing of the thesis. My thanks also to all the other staff and researchers at the University who have made helpful comments throughout this period.

Finally I would like to thank my family and friends for all their support. To those who have read through earlier drafts to the thesis and commented on it; to those who have let me talk to them when I have had a problem; and especially to my extended family at St James who have given my much needed spiritual support throughout the whole research process.

Index

List of Tables and Figures

Chapter 1 Introduction

The number of students studying physics post compulsory education is recognised by the government and those working in industries that employ STEM (science, technology, engineering and mathematics) graduates as being too small to meet the future demand for physicists. The UK government (DIUS, 2009) has asserted that to continue as a wealthy nation there needs to be an increase in the number of STEM qualified entrants into the workforce. The proportion of students taking AS and A-level[1] physics who are female has remained at about 20% for a number of years. Increasing the number of girls taking physics could be one way of increasing the overall number.

The issue of why more girls do not study physics and other physical sciences, including engineering, has formed part of the 'women in science' debate for many years. This issue has been the concern not only of the policy makers mentioned above but of those working in the STEM sector, teachers and activists. Initiatives started to appear from the 1970s onwards (Phipps, 2008) when, in the UK, acts to ban discrimination and to give equal pay started to be introduced in the workplace. These initiatives included classroom based action research interventions, after school and residential courses for pupils, support and networking for female STEM students and professionals and training programmes for socially excluded women (Phipps, 2008). Even after these many years of initiatives, women are still under represented in the STEM workforce, especially the physical sciences. There is still a need to investigate why equality has not yet been achieved or, as is the case with A-level physics entries, why the proportion of girls taking the subject has not changed.

In this first chapter, I outline the key issues and give an overview of the structure of the thesis as a whole.

---

[1] For explanation of these terms, see next section on science education in England.

Science Education in England

Science is taught in English and Welsh schools as part of the National Curriculum. Schools in England and Wales follow a similar National Curriculum, similar examinations and have a similar schooling system, although there are some anomalies in Wales. The schooling system in Scotland and Northern Island, the other two countries that form the United Kingdom at the time of writing, have their own schooling system, curriculum and examination systems. This introduction to science education is therefore a description of the English system alone.

Education in England is compulsory and free at state schools for all children from the age of five until 16 (which rose to 17 in 2013) and all young people have to remain in some form of education or training up to the age of 18. School years are numbered with children starting school in year 1 and taking their GCSEs in year 11. The majority of children start their secondary education at age 11 but in some areas of the country they do not start it until age 13. The majority of secondary education takes place in schools that cater for 11-16 year olds or 11-18 year olds. At the age of 16 the majority of children[2] take General Certificate of Secondary Education (GCSE) examinations. These are in the core subjects of English, mathematics and science as well as other subjects chosen by the individual student.

The majority of secondary schools in England are non selective, comprehensive, mixed sex schools. The intake to these schools varies depending on the location of the school and the socioeconomic nature of the population in that location. There are a small number of fully selective schools where students must pass an examination to gain entry. There are four main types of state schools in England. These are community schools which are funded by the local council; foundation schools which have more freedom to deliver their own curriculum than community schools; academies which are publicly funded independent schools and can deliver their own curriculum; and selective grammar schools. A small

[2] Some children with special educational needs do not take GCSE examinations.

number of Free schools have been established recently that are funded by central government and do not have to follow the national curriculum.

The majority of schools teach following the national curriculum. Students must study science as part of this curriculum. When they take their GCSE examinations, they can take two GCSEs in science where they study a combination of biology, chemistry and physics or three GCSEs, one in each of the separate sciences. Schools are encouraged to enter those students who have higher attainment for the three separate science subjects. GCSEs are graded from A^* (the highest grade) to G. Grades A^* to C are considered to be the best grades.

Once students have completed their GCSEs there are a number of options for further, post 16, study. One of these is to take Advanced Level (A-level) qualifications at the age of 18. In the first year of post 16 study, students who are following an A-level programme will take Advanced subsidiary (AS) examinations. They can then continue to study the subject for the full A-level, taking this examination after another one year of study. Students usually study three or four subjects at A-level. In England, A-levels are regarded as the standard entry requirements for many university courses. A-levels are grades A^* (the highest grade) to E with all grades considered as pass grades.

Participation in A-level Physics

Since the introduction of Curriculum 2000 (DFEE, 1997) in 2000, the last major change in A-levels, the numbers studying A-level physics dropped to 23657 in 2006 from 28191 in 2000 but has then risen to 29206 in 2011. During the same time the number of girls studying A-level physics has dropped from 6396 in 2000 to 4970 in 2006 and back up to 6013 in 2011. The percentage of girls studying A-level physics as a proportion of the overall entries has remained constant at about 20 % (see chart 1-1 below, based on DfE, 2012).

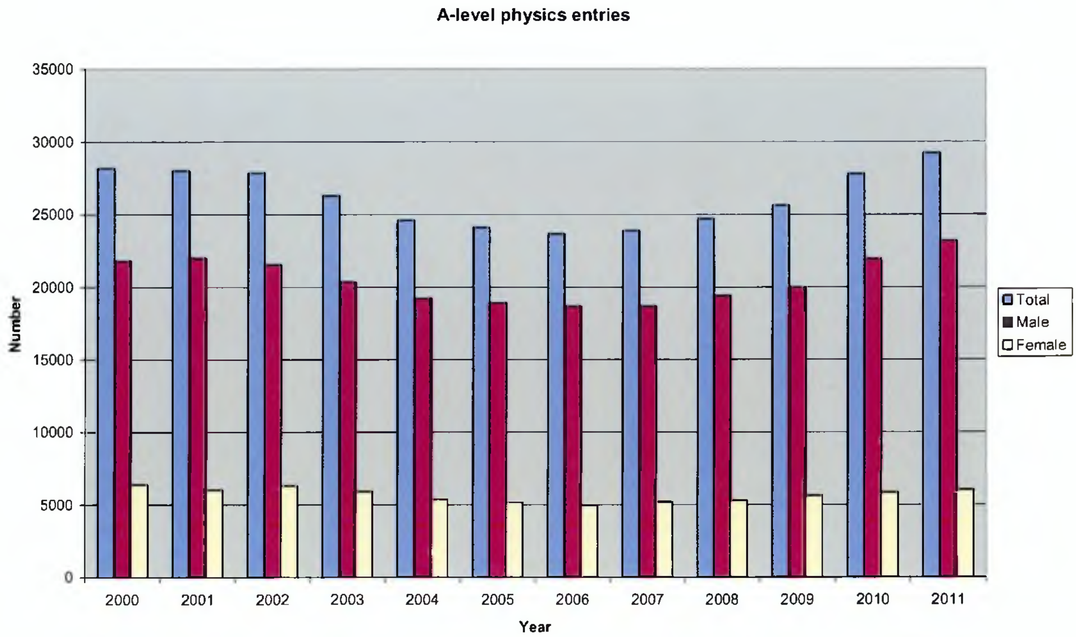


Chart 1-1 – A-level Physics Entries 2000-2011

Curriculum 2000 introduced a split from the traditional two year A-level into a 1+1 A-level where an AS qualification is taken in the first year and then a full A-level, via an A2 examination, in the second year. This has allowed students to take a wider range of subjects in their AS year. The numbers studying for AS level physics are therefore higher than those taking the full A-level. In 2011 there were 49079 entries for AS level physics from 37689 boys and 11390 girls (see chart 1-2, based on DfE, 2012).

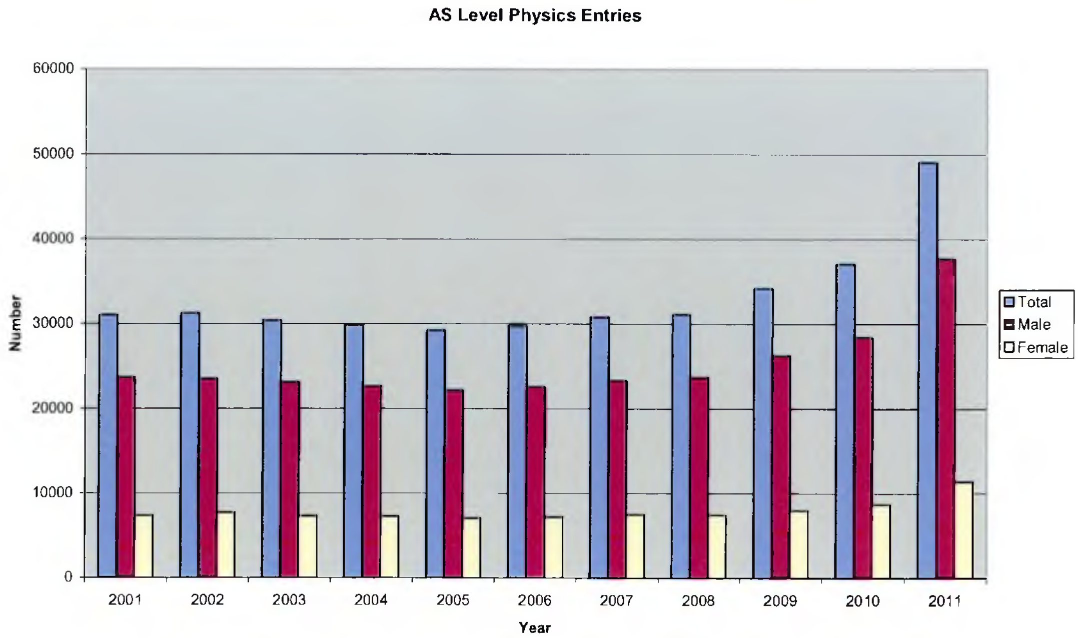


Chart 1-2 – AS level Physics Entries 2001-2011

A more detailed interrogation of the 2011 data from the National Pupil Database (a database held by the Department for Education recording all school pupils) was carried out by the Institute of Physics (2012). This investigation not only looked at the numbers of students entered for A-level physics in 2011 but also patterns in progression data from GCSE to A-level. Girls and boys achieve equally well in GCSE science or physics so there should be no difference in progression based on prior achievement. However they found:

- that 46% of all schools did not send any girls onto A-level physics compared with 14% for boys
- that independent and single sex schools were more likely to send girls onto A-level physics
- that students are less likely to progress to A-level physics from 11-16 schools than from 11-18 schools
- that the overall academic achievement of a school affects the percentage of girls progressing to A-level physics with the higher the achievement the higher the progression
- that socioeconomic background affects progression for all students.

The Institute of Physics followed this report up with one looking at the gender balance in schools with respect to six 'gendered' subjects (IOP, 2013). They found that four out of five state-funded co-educational schools did no better than the national gender ratios for progression onto these A-level subjects (which were English, mathematics, biology, physics, psychology and economics). The majority of schools were, therefore, maintaining the gender stereotypes of these subjects.

Boaler, Altendorf and Kent (2011) have also recently investigated performance and participation patterns in mathematics and science in the United Kingdom. They found that girls who do take A-level physics get a slightly higher proportion of the highest grades A*-C than boys. They also found that only 13% of girls who gain an A* (the highest possible grade) at GCSE progress onto A-level physics compared with 64% of boys. Therefore, attainment is not a barrier to progression.

These two recent reports do not give answers to the problem, just highlight that there are still differences that need to be investigated further. The concern about the small percentage of girls who take A-level physics, and the low progression rate of high achieving GCSE girls compared with boys, led to the Institute of Physics publishing two booklets looking at the question of 'Girls in Physics' in 2006. One of these was a review of literature by Murphy and Whitelegg, discussed in detail in Chapter 2, and the other was a handbook of suggestions for teachers. Murphy and Whitelegg's review of the literature showed there was a gap in the literature about 'girls' experiences of science and physics in schools in England and how this informs their attitudes and future aspirations' (Murphy and Whitelegg, 2006a, pvi). One of the responses following the publication of these booklets was an action research project where physics teachers carried out small, in-school projects to look at strategies for increasing the participation of girls with physics in their schools (Institute of Physics, 2010). Strategies suggested in this work included the use of role models, one day physics-related careers workshops and using a 'girl friendly' checklist for classroom activities.

Two major research projects, both funded by the Economic and Social Research Council, the UPMAP project (Understating Participation rates in post-16 Mathematics And Physics) and the ASPIRES project (focusing on primary age children) have looked at the issue of low participation in science subjects in England recently. Both projects used a combination of a large quantitative survey followed by qualitative interviews to research the issue. The ASPIRES project used an on line survey (Archer et al., 2013) completed by 9319 students aged 10 or 11 and interviews with 78 parents and 92 students. The students who completed the questionnaire will be re-surveyed at a later date. The interviews were single visit interviews. The UPMAP project intends to interview 70 students aged 15 and then re-interview them at age 16 and 17 (UPMAP, 2008).

Even though there has been a great deal of research about why girls still do not study physics (and to some extent the other sciences) in higher numbers post-16, there are still areas to investigate with regard to this question. One area that has not been studied in depth is how identification with physics influences choice. This is the area that this study focuses on.

Researching Identity, Self Efficacy and Girls' Physics Choices

This thesis contributes to this developing body of knowledge by examining why girls choose or do not choose to study physics for A-level through a focus on physics identity and physics self efficacy. The aims of the research were to:

1. interrogate the current literature on identity and self efficacy to develop definitions of physics identity and physics self efficacy and then to develop a theoretical model linking the two
2. explore what physics identity and physics self efficacy meant for girls in school years 9-11 and produce narratives to examine how these impact on future subject choices.

I proposed a theoretical framework for physics identity using the theories of Jenkins (2009) and Gee (2001) which was developed in figured worlds (Holland et al., 1998). Although there is a growing body of literature using figured worlds to describe science identities, this has not been in the area of physics identities nor in England. I also argue that physics self efficacy forms a part of physics identity and these two phenomena have not been linked in such a direct way before. Much work investigating choice in the past has been done quantitatively. Investigating choice as part of identity work and using a narrative approach (telling individual stories of girls' identification with physics and how this impacts on their choices) is a new area to which this work contributes.

A pilot study completed for my Masters thesis (Thorley, 2010) which investigated why girls had chosen to study A-level physics, gathered data from girls who had completed the first year of their A-level programme. These girls had chosen physics both for interest and to support future career goals. The findings from this study were used to inform the present study but were excluded from the current data set.

Previous research on identity and self efficacy has been carried out, independently, in two different disciplines and using a wide range of different theoretical frameworks. The result of this is confusion about what the terms 'physics identity' and 'physics self efficacy' actually describe. The research presented here contributes to the development of a theoretical model linking physics identity and physics self efficacy. It was developed by considering the choices, identity and self efficacy of girls at two schools in England. The proposed model was refined and used to examine the impact on future subject choices.

This research used a mixed method approach. Two schools were identified where they had a higher than average (20%) percentage of girls in their A-level physics classes; these were atypical schools in that they had a high proportion of students from a White, high socioeconomic grouping background. An initial questionnaire was given to all year 9 and 10 pupils at the two schools. Using these questionnaires, 43 girls, including both those who had expressed a possibility of choosing A-level physics in the future and those who had not, were selected to participate in three rounds of small group interviews. These interviews investigated the reasons for those future subject choices, the factors that influenced them, and aspects of identity and self efficacy linked to physics. Finally, narratives for four girls were developed to illustrate how physics identity and physics self efficacy impacted on their choice not to study physics for A-level.

Introducing My Position as a Researcher

Given both the qualitative nature of the methodology used in this research and the focus on identity and self efficacy, it is important to introduce myself. I form an important part of this research. You cannot participate in qualitative research without part of yourself influencing the decisions you make methodologically. My background affected how I interacted with the girls I interviewed and how I produced their narratives. Knowing a little about me will help the reader to place this research in context.

My name is Deborah and I am a...If I make a list of who I think I am this list would look like : I am a woman, I am a sister, I am an aunt, I am a chemist, I am a teacher, I am a bellringer, I am a family historian and a few more. At the beginning of this research nowhere on that list would be 'I am a social scientist'. As I am nearing the end of this research I still do not feel that I am a social scientist but I would say that I am beginning to understand what one is and that I am starting to think like one some of the time.

I made the decision that I wanted to be a scientist at about the age of fourteen when I was choosing my Ordinary Level (O-levels)[3]. I knew then that if I wanted to become a scientist I would need to study all three sciences for O-level, even if my headteacher felt that this would make me a one dimensional person and tried to encourage me to only study two of them and choose another humanities

[3] O-levels were the precursors to GCSE.

subject instead. But I was adamant; I wanted to be a scientist and therefore I needed to study all three sciences. This did prove to be the case when I started looking for university courses and the number you could apply for was greatly reduced if you did not have all three sciences for O-level. At this time I was thinking of biochemistry, but eventually I studied chemistry and really enjoyed that.

I cannot really remember what made me so interested in science, but I have always liked facts. I like being able to give the correct answer to a question. I can define water as being two atoms of hydrogen linked to one of oxygen to give the molecule water. I know that there are many aspects about the properties of water that are still unknown, but a molecule of water is always the same. One of my issues with the humanities and social science has always been that you can discuss things and interpret your answers. I read a book and enjoy it, but don't want to discuss why the author wrote it in a certain way or what you can deduce from how they described a character. This was my biggest issue when researching identity and self efficacy for this thesis. There is not one definition. Identity and self efficacy can be described in many different ways. One of the aims, therefore, of this research was to develop a definition of physics identity and physics self efficacy that would help me, and others (especially physics teachers), to explain how these factors influence girls (and boys) when they are making their choices about what subjects to study post 16.

Paradigmatically speaking I have worked in a positivistic way for many years. As a teacher, I moved towards post positivism as a way to understand the involvement of the individual in learning. Changing my world view to encompass more of how individuals construct their meaning of the world has been, and still is, a painful journey at times. Further discussion on these issues can be found in Chapter 4.

The Thesis Outlined

Chapter 2 of the thesis gives an overview of some of the current literature on girls and physics. It starts with an historical view of 'the problem' of girls in science then continues by looking at three recent reviews on the issues. Using these reviews as a starting point, I then look at the different themes that have been used to investigate the relationship between girls and physics (and science and mathematics where relevant). I use five themes and propose that these are a good framework for future reviews of the literature.

In Chapter 3 I develop a description of physics identity based on the work of Jenkins (2009) and Gee (2001) and which is developed within figured worlds (Holland et al., 1998). I then interrogate how identity has been used by others to describe science and physics identities. In this Chapter I also interrogate the literature about self efficacy to show one way in which identity and self efficacy can be linked. This results in a theoretical framework that I use in the analysis of my data.

In Chapter 4 I describe the methodological journey taken during the project. The project started life as a two school case study. The methods included in the case study were a questionnaire to gather background data about pupils in year 9 and 10, small group interviews with girls who were both thinking of and not thinking of choosing physics for A-level, lesson observations and investigating supporting documentation for the schools. As the research developed, the emphasis changed to using the small group interviews as the main data gathering tool. Following thematic analysis of the interview data, a final methodological change was made to using narratives. Throughout the discussion of methods, I interweave a discussion of my methodological thinking.

The schools chosen as research centres are described in Chapter 5. In this Chapter I also present the findings from descriptive analysis of the questionnaire data. Data for both girls and boys is discussed and compared for similar and different trends. Similarities and differences in the data for those pupils who were thinking of choosing physics and who were not thinking of choosing physics is also compared. Comparison of the data to similar data sets is also described here.

I introduce the girls chosen for the group interviews in Chapter 6, explaining the reasons for my choices. The group interview data is analysed using both deductive and inductive themes. These themes are explored and quotes used to illustrate the points made. New contributions to the debate on why girls choose or do not choose to study physics post 16 further are identified and discussed. The findings show that girls' choices are impacted by teacher – student interactions with special regard to physics confidence, by the discourse of achievement and by the complexity and interrelationships within figured worlds. The findings also show that there are many similarities as well as differences between both physics choosers and physics non choosers.

Chapter 7 presents the narratives of four girls. I used a narrative approach to analyse their stories and so present them in this way. These narratives illustrate that many factors influence a girl's identification with physics (including her physics self efficacy) and her possible future choice as to whether to study the subject post-16 or not. For some girls there are significant points in time that can be identified as having a major impact on her identification with physics and that can change her physics identity trajectory. For others, it is a combination of factors that either push her away or pull her towards physics. For each girl, the importance of the different influencing factors, and the amount of push or pull they have, is different. It is the overall combination of these influencing factors that impacts on her identification with physics and her ultimate choice as to whether to study it further or not.

Chapter 8 concludes the thesis. I present a summarising discussion of how physics identity and physics self efficacy and the factors that influence them can be used to understand subject choices. For each of the knowledge claims I discuss the implications and make recommendations for action. I finish by discussing the limitations of my research and make suggestions for future studies.

Chapter 2 Girls and Physics

Introduction

In this chapter I discuss previous research literature about girls and physics. I start the chapter by putting the issue into its historical context by giving an overview of the history of the gender and science argument. I continue the chapter by looking in more detail at the recent reviews written by Blickenstaff (2005), Brotman and Moore (2008) and Murphy and Whitelegg (2006a) before adding to these discussions with a review of the more recent literature.

My review of the literature starts by looking at how general attitudes to science and physics can influence students' choices as to whether to pursue a study of these subjects past compulsory education; I then move on to look at the choice literature in more detail. Separating out the attitudes literature from the choice literature can be problematic at times since there is overlap between the two bodies of literature, but this differentiation seemed appropriate for this thesis since it focuses on choice rather than attitudes.

I begin by looking at choices in general, focusing on science subject choices, before moving on to look at how choices are linked to future careers. I then move on to look at how teachers and teaching and significant others can influence future subject choice. I close with looking at the image of physics as an influencer of choice. This section looks at how stereotypical views of physics as being a hard subject, a masculine subject and primarily for White, middle class males can influence choice.

Gender and Science – a Historical View

In his recent book (2011), written to encourage more girls to study physics, 'Fizz nothing is as it seems', Zvi Schreiber takes his eponymous heroine on a trip through time to meet the giants of physics. Of the 116 people she either meets directly or discusses, only three (Marie Curie, Fabiola Gianotti and Caroline Herschel) are women. This illustrates how few famous women physicists there are and how long this problem has existed.

It was in the 19th century that the foundations were laid for the studying of science that we have today. Until that time, the study of science had been predominately a hobby for men of independent means. Any women who did participate, for example Caroline Hershel[4], did so because of the support of their family (in her case her brother). During the 19th century access to an education became more widespread with even the poorest children becoming entitled to a basic level of education. The studying of science became more important as the Industrial Revolution grew.

19th century science focused on the notions of certainty, measurement and control. Science was characterised by positivist thinking that empirical experimental research yielded quantified and quantifiable data. Science was seen as objective. Objectiveness was seen to be a male characteristic and so science was not open to women who were deemed unable to be rational and objective.

This differentiating of the sexes also developed during the 19th century and was, as McAteer (2000) describes, in part due to the work of Darwin. Darwin published his *On the Origin of Species* in 1859 which described the theory of natural selection. In 1871 he published *The Descent of Man* which applies natural selection to human beings. This work was used to justify the imbalances of power between individuals, races and nations by saying that some were more fit to survive than others. These biological causes of human behaviour could be used to explain differences between the sexes. Based on their differing anatomy,

---

[4] Caroline Hershel was a German-British astronomer who discovered several comets.

men and women were described as being not equal but complementary opposites. This allowed for the division of roles and labour based on sexual differences. Therefore women could not participate in activities deemed suitable for men, for example, science, due to their sex.

McAteer goes on to argue that the school science curriculum was, and still is, influenced by universities. Universities see school education as a preparation for studying at their institutions. University science in the 19th century became dominated by experimental, laboratory based science. Therefore the early school science curriculum could be termed to be a scaled down version of this. This version of science was seen to be most suited to 'able' students who in the 19th century were white, upper and middle class males. This became the stereotype for a typical science student (see later section for more discussion about stereotypes in science). The science that was offered to girls was that which was deemed suitable for their development into good wives and mothers; namely, domestic science.

As the 20th century progressed, school science continued to be seen as a preparation for further university level study. Girls did enter scientific professions, but many of these professions were closed to married women so choices had to be made. In the early and middle 20th century school science still operated within a gender divide. Biology was seen as a girls' subject and physics as a boys' subject. Many girls did not have access to physics teaching[5].

Progress was made with the introduction of the National Curriculum in 1988 which made the study of science until age 16 compulsory. Until then choices were made at age 14 as to what subjects to study. The number of girls who chose to study physics was still low during the 1970s and 80s so schemes started to be put in place to encourage more girls to study science (e.g. GIST (Girls into Science and Technology) and WISE (Women into Science and Engineering); see Phipps, 2008 for a review of UK initiatives).

---

[5] My mother had to go to the local boys' grammar school to study physics in the 1940s as her girls' grammar school did not have a physics mistress and boys came to her school to study biology.

Research, which started in the 1970s and 1980s, on the girls and science 'problem' focused mainly on two issues of science provision; that of the differential involvement of girls and boys in science and that of the differential achievement of girls and boys in science (Bennett, 2003). Research on the differential involvement of girls and boys in science also looked at their attitudes to science as gender was seen to be a determining factor of attitude. These areas were focused on because in a time of equal opportunities there was a need to investigate the factors that impeded girls' achievement in science; and because it was conjectured that girls were avoiding science due to its perceived male nature (see reviews of Kaminski, 1982 and Manthorpe, 1982).

Further reviews in the 1990s (for example: Acker and Oatley, 1993; Catsambis, 1995 and Kenway and Gough, 1998) continued to look at the issue of under-representation of girls in science, in both education and the workplace. As Kenway and Gough argued, 'the notion of enhancing girls' post school options should also encompass the wider economic, social, cultural and environmental conditions in which they live their lives' (p24) not just focus on short term fixes.

In the next section I look at three more recent reviews about 'girls and science' and 'girls and physics'. These show that many of the same issues identified in earlier work are still of concern to science educators but also that there is beginning to be an emphasis on identity and self efficacy (see Chapter 3 for a more in depth discussion of these two areas).

Recent Reviews of the Literature on Girls in Science and Physics

The three reviews discussed in this section are those of Blickenstaff (2005), Brotman and Moore (2008) and Murphy and Whitelegg (2006a).
Blickenstaff (2005) reviewed the literature looking at the absence of women as STEM majors in the US looking at whether they were leaking from the

'pipeline'[6] naturally or whether these leaks were some form of gender filter. Blickenstaff identified nine explanations that had been put forward in the various STEM education research literatures to explain why women do not study or work as scientists. These were:

1. biological differences between men and women
2. girls' lack of academic preparation for a science major/career
3. girls' poor attitude toward science and lack of positive experiences with science in childhood
4. the absence of female scientists/engineers as role models
5. science curricula are irrelevant to many girls
6. the pedagogy of science classes favours male students
7. a 'chilly climate' exists for girls/women in science classes
8. cultural pressure on girls/women to conform to traditional gender roles
9. an inherent masculine worldview in scientific epistemology.

(p371-372)

As Blickenstaff says, many of these nine explanations interact so intimately that each alone cannot be used to explain the shortage of women in STEM. After looking at the literature, Blickenstaff rejected biological factors as an explanation, because of the lack of evidence to support differences in ability, and also academic achievement, because even girls who out performed boys dropped out of STEM subjects. Girls' attitudes were found to differ from those of boys and that could be due in part to the lack of role models, the design of curricula that favour, what are suggested to be, boys' preferred ways of learning and teaching methods that devalue the contributions of girls. The final three explanations focus on social and cultural factors that support the generalised view that science is for White, middle class males. Blickenstaff concludes that the issue of 'girls and science' is a complex one that requires a multi-faceted solution.

[6] Pipeline – the term used to describe the movement of girls through science education and onto a science career. The term, as used here, implies that the girls are perceived as a resource for the STEM industry.

Brotman and Moore studied research published between 1995 and 2006 in five major peer reviewed science education journals and two other respected journals that publish on a range of issues including girls and science[7]. They reviewed 107 studies from around the world that dealt with pre-college education. The research in these 107 studies looked at issues that related to girls or gender and science. Research that was not included in the review was articles that focused on the effectiveness of single-sex education or where girls or gender and science were not a primary focus of the research. Reviewing these 107 articles for their purpose, participants and setting, methodology and major findings lead to Brotman and Moore grouping the research into four themes that reflected the current trends in science education generally. These were:-

1. a focus on equity and access
2. a focus on curriculum and pedagogy
3. a focus on reconstructing the nature and culture of science
4. a focus on identity.

They found that the order of these themes also revealed a trend in the movement of the focus of research on girls or gender and science education over time with the number of papers on the first themes diminishing whilst those on the final theme becoming more prevalent since entering the science research arena in 1995.

The first theme covered research looking at both the inequalities faced by girls in science and work done to provide equitable science opportunities. They looked at the differential treatment of girls in science classrooms, the gender bias in textbooks and how these contribute to different levels of participation, achievement and attitudes towards science of girls and boys. Intervention programmes where girls were given access to out-of school science experiences and female role models as well as teacher education measures were also discussed.

[7] The journals were Journal of Research in Science Teaching, Science Education, International Journal of Science Education, Research in Science Education, Journal of Science Teacher Education, American Educational Research Journal and Gender and Education

The literature grouped in theme two described the argument that there needs to be change in curricula and pedagogy in order to engage girls in science. Data gathered in research in theme one was used to underpin the arguments for such changes. Research discussed in theme two looked at girls' learning styles and interests, how teachers' views and experiences impacted on pedagogy and at interventions where curricula labelled as 'gender inclusive', 'gender balanced' and 'girl friendly' were trialled in the classroom.

The need to challenge the portrayal of the nature and culture of science as being masculine, objective and difficult in order to attract more girls (and other marginalised groups) into science was the focus of theme three. Research describing these issues and that they needed to be acknowledged by both teachers and society before change could happen was described. Research investigating teachers' views on these issues was also described.

The final theme, identity and how there is a need to incorporate science into the developing identities of girls, will be discussed in more detail in the next chapter.

The reviews of Blickenstaff (2005) and Brotman and Moore (2008) looked at science education in general (as discussed in Chapter 1). In 2006 Murphy and Whitelegg (2006a) produced a report for the Institute of Physics reviewing the literature on the participation of girls in physics. They reviewed the literature mainly from 1990 to 2005, but included earlier research if these studies had important messages for the review or if the current literature was lacking. The focus was on UK based research but non-UK based research was included to widen the scope in some areas and if it was deemed to be transferable to a UK context. Much of the pre-16 research did, however, have an overall science focus since many UK students study GCSEs in combined science rather than in the separate sciences and the research was into GCSE science rather than the more minority subject GCSE Physics. In all 177 literature sources were included in the review.

Murphy and Whitelegg, after analysing the literature in their review, found that it could be grouped into six themes that reflected the emphasis placed by researchers and their work investigating the girls and physics 'problem'. These were:-

1. interests, motivation, course choices and career aspirations
2. relevance and curriculum interventions
3. teacher effects
4. single-sex schooling and groupings
5. measures and perceptions of difficulty
6. entry and performance patterns in physics: the impact of assessment processes and techniques.

They found that the key determinants of students' attitudes to physics and their willingness to study it post 16 were:-

1. how students saw themselves in relation to the subjects, both now and in the future: their 'physics self concept'
2. their experience of school physics
3. a personally supportive physics teacher.

(Murphy and Whitelegg, 2006a, piii)

Murphy and Whitelegg themselves highlighted what they felt were important issues from this literature review in a follow up paper in 2006 (2006b). They reiterated that there were a number of factors that influenced girls' choice to study physics post16 and that there was no 'quick fix' to 'the problem' of girls and physics. They suggested that 'a fundamental reconsideration of the contribution of physics to students' future lives' (p300) is needed for change to occur.

These three more recent reviews looking at girls and science and girls and physics all highlight that 'the problem' is a complex one that has been investigated from a variety of different perspectives. They all show that focusing on just one issue is not going to increase the number of girls choosing to continue to study science and/or physics or to choose to follow a science or physics based career. A move towards looking at 'the problem' within the wider social and cultural factors that make up the world of today has started to emerge. These reviewers encourage future work in the area to be carried out with this more holistic viewpoint. It is intended that sections of this thesis contribute to this more holistic perspective.

These reviews provide a background to the rest of this chapter. As Murphy and Whitelegg (2006a) found, 'there is little information about girls' experiences of science and physics in school in England and how this informs their attitudes and future aspirations' (pvi). I have therefore included non-English based research in the following discussion where this supports and extends the English research base.

General Attitudes to Science and Physics

Most of the research into attitudes has been quantitative research with both boys and girls and into science in general; only a few researchers have focused on physics or reported findings on physics separately. Quantitative research can generate large databases of responses, effectively showing patterns in the data; but they usually lack the depth to answer why pupils have a given attitude to science. A limited number of qualitative research papers have started to emerge in the past 10 years, some of which have followed a larger quantitative survey.

A major review of the literature about attitudes to science was carried out by Osborne, Simon and Collins in 2003. They reviewed 141 literature sources concerning attitudes to science from 1980. They found that researchers were giving increasing attention to the topic of young people's attitudes to science which was driven by a recognition that all is not well with school science. In general they found that young people's attitude to science was not positive and many were being alienated from the subject. Overall, they suggested that when pupils take control of their own learning, for example, by carrying out extended investigation and discussion, they will have more interest in the subject. However, they found that although a lot of the research identified the problem, there was not much that said specifically how the problem might be overcome. An update of this review was produced by Osborne, Simon and Tytler in 2009. They identified five themes where work on attitudes had taken place in the 2000s. These were:

1. the measurement of attitudes
2. engaging young people in science
3. gender
4. identity
5. large datasets.

There are many methods used in the research to both measure an attitude towards science and to define what is meant by the term. Blalock et al. (2008) carried out a review of 66 instruments for measuring attitudes. They found that many researchers in this area used their own instrument and that these had not been rigorously tested to establish their validity and reliability. If the results of an attitude measure are to have statistical value, then the instrument used needs to meet the standards now expected from good psychometric measures.

For many years boys have consistently demonstrated a more positive attitude towards science than girls. For younger children, i.e. primary children, it has been found that there is no gender difference in attitude and interest in science. The differences in attitude are formed in early secondary schooling and by the age of 14 most students have already decided whether they will pursue an interest in science post compulsory schooling or not. A decline in a favourable attitude is more pronounced for girls. However, this decline in attitude is usually measured towards science in general, not for specific subjects or areas of science. Haste (2004) found that perceptions of science related to personal, social and ethical values. She found that for girls, the context, purpose and implications of science were important. Ethical factors related to science were a particular positive factor for girls to improve their interest in science but were a negative factor for boys. Masnick et al. (2010) also reported that students did not view science careers as particularly creative or to involve interaction with others; aspects that were important especially to girls when choosing future careers.

Research focusing on identity in science will be discussed in the next chapter. The continuing worry about the number of students studying science and technology subjects post 16 and the impact this has on a country's economy has led to the funding of national and international studies, for example, ROSE (Relevance of Science Education Project), TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment). Attitude questions were included in each of these surveys and data from them can be used to analyse attitudes towards science for students from many countries. Jenkins and Nelson (2005) report some of the findings from English schools involved in the ROSE survey. This showed that few students liked school science better that other school subjects or aspired to become scientists. Girls were more likely than boys to disagree that school science was easy to learn. Girls also preferred non physical science topics. (These same findings are reported by Quinn and Lyons (2011) in Australia). Using data from PISA, Buccheri, Abt Gurber and Bruhwiler (2011) found the expected gender differences in attitudes to the different science subjects between the genders were also reported in four countries that they studied (Korea, Finland, Australia and Switzerland).

An investigation of attitudes using a longitudinal approach forms the basis of a small study carried out by Reiss (2004). He worked at one non-selective 11-16 school in southern England and followed 21 pupils in a mixed attainment science group throughout their time in the school. He carried out interviews with the pupils each year as well as lesson observations, teacher interviews and parent interviews to explore their attitudes towards science and science lessons. For four of the pupils he produced an in depth narrative of their changing attitudes towards science over time. He found that all four of these pupils entered the secondary school with an enthusiasm for science which dissipated over the next five years. One of the main influencers on these pupils' attitudes towards science was their teachers (see later section in this Chapter for more about teacher influences on student choices).

The impact of an extracurricular activity on pupils' attitudes to science was investigated by Barmby et al. (2008) in their paper about the impact of the "Lab in a Lorry" project. They surveyed 932 11-14 year old pupils about their attitudes both before and after they were involved with the project. They also carried out follow up interviews with 44 pupils at five schools involved with the project. They again found that there was a steady decline in attitudes towards science as pupils got older and that this decline was more pronounced for girls.

Research into attitudes towards particular science subjects rather than just science altogether is less widely available. Spaull et al. (2003 and 2004) looked at attitudes towards physics and biology with both secondary pupils and undergraduates. Using the same questionnaire they surveyed 1395 school pupils (both male and female) (selected from pupils in years 7 to 11 in six mixed comprehensives in the North West of England) and 439 first year undergraduates (selected from English, physics and biology students) about their attitudes to aspects of biology and physics. This was a cross sectional rather than a longitudinal study. They found that positive responses to liking physics dropped from 64% in year 7 to 29% in year 11 with a corresponding increase in the number who found physics boring. There was also a drop in liking biology but only from 61% in year 7 to 52% in year 11. Pupils thought that biology was more relevant to their everyday life than physics and was more likely to contribute to solutions to environmental and medical problems. The English undergraduates thought that physics was less attractive, less interesting and less likely to solve problems than biology. Amongst the biology undergraduates there was a small subgroup who also liked physics. Generally, however, the biology undergraduates thought of physics as a mathematical subject that was less likely to solve problems than biology. As expected, 95% of the physics undergraduates liked physics. Interestingly, 48% of them thought that males were better suited to physics than females (see section later in this Chapter on stereotypes for further discussion on this topic).

A recent attempt at using a survey that also provided more detail was by Bennett and Hogarth (2009). They devised a survey instrument asking about both school science and science outside school that had two levels of question. The level one question was a straightforward statement (for example 'If I had a choice I would study physics') to which the respondents answered agree, neither agree nor disagree or disagree. The level two question then asked respondents to tick a range of reasons under their first response. The results showed that overall positive attitudes to school science and science outside of school decreased from age 11 to age 16 with females being less positive than males throughout. Attitudes to science outside of school were generally more positive than to school science.

Research on attitudes towards science in other countries has found similar results to those reported above for UK pupils. For example Jones et al. (2000) and Miller et al. (2006) working in the US found that girls have a less positive attitude towards science than boys. Girls were found to be more people orientated so, of the sciences, found biology of more interest to them. When they did like science girls did so because they liked the teachers and also the subject matter. Work by Baram-Tsabari and Yarden (2008 and 2011) in Israel and the US looking at questions submitted to online science forums found that girls submitted more questions about biology than boys whereas boys submitted more questions about physical science topics.

In summary, the literature on attitudes towards science and physics reports that, in general, young people's attitudes become less positive as they get older with the most rapid decrease in positivity occurring during secondary education. Girls are reported as having a less positive attitude than boys. Attitudes towards physics, in particular, are also found to be less positive than towards other sciences. Many factors influence these attitudes including teachers and cultural and social aspects of how science is viewed. Attitudes towards science are closely linked to whether a student chooses to pursue studying a subject or not. The next section explores the choice literature but overlaps with the attitude literature will be observed.

Choices

There are many reasons why girls do and do not choose to continue to study physics post 16. Holmegaard et al. (2012), when discussing Higher Education choices in general, highlighted that choice research in this area can be categorised into three traditions. British choice research looks at understanding how a student's background, especially their social class, can affect choices and access to Higher Education. This research uses both quantitative and qualitative methods (for example, quantitative surveys and narratives (Reay, David and Ball, 2005); longitudinal case studies (Brooks, 2003); and focus groups (Read, Archer and Leathwood, 2003)). American choice research is mainly quantitative and makes use of comprehensive choice models (for example, Eccles et al. (1983)) that investigate how ethnicity, gender, social class and prior high school trajectories impact on choices. The tradition in Scandinavian research (for example the work of Holmegaard et al. and Boe et al. (2011) described below) is to relate student choices to their construction of attractive identities. They argue that choice is socially constructed in society in general. These traditions can also be found in choice research looking at subject choices before Higher Education.

As described by Holmegaard et al. (2012), American research on choices makes extensive use of choice models, one of the most popular being the expectancy-value model of achievement related choices (Eccles et al., 1983). This model, grounded in social psychology, has been used to investigate enrolment in college mathematics and English courses (Eccles, Vida and Barber, 2007); to high school course enrolment in mathematics and science (Simpkins, Davis-Kean and Eccles, 2006); and choices in relation to physical science, engineering and applied mathematics (Eccles et al., 1999) to give a few relevant examples. The expectance-value theory is based on the idea that an individual's choice, persistence and performance can be explained by their beliefs about how well they will do in an activity and the extent to which they value that activity (Wigfield and Eccles, 2000). More recently, Eccles (2009) has come to think of identity as a motivational construct. This then forms a link between this expectancy-value model and identity formation, a concept that is discussed in more detail by Boe et al. (2011).

Boe et al. (2011), working in Norway, discuss how the various aspects of the expectancy-value model are linked to not only identity, but self concept and the society as a whole. They focus on five aspects of the model and relate them to STEM choices.

1. Interest enjoyment value

   That young people have a low interest in school science subjects and that boys and girls interests differ
2. Attainment value

   That many young people cannot see themselves as 'science people' especially young women who see science identities as not attractive to them
3. Utility value

   That STEM subjects can be gatekeepers to careers and that the hardness of science will be tolerated if they are useful for the future; however, girls especially worry about failure (they have a lower self efficacy)
4. Expectation of success

   That physical sciences and mathematics are seen as hard and achievement is linked to self efficacy
5. Relative cost

   That the physical sciences and mathematics have a high cost due to difficulty. This is a negative aspect of choice. Girls also see a cost in male dominated areas

Using this discussion of the Eccles et al. model, Boe (2012) found that when choosing subject programmes, the Norwegian students wanted one that would be interesting, meaningful and self realising. Of the five components, utility value was especially important for science students and was higher for girls than for boys. Looking specifically at physics students, Boe and Henriksen (2013), found that they could be categorised into three groupings. There were those who chose physics for both intrinsic and extrinsic motives (interest, utility value, expectation of success and a fit to personal beliefs); those who focused on extrinsic motives (highly valuing the utility value of physics but having a low interest); and those who chose it for intrinsic motives (interest, self realisation but low interest in the utility value). They found that more students from the intrinsic category went on to study physics at university than from the other two categories and that this category was the one with fewest females in it.

Positioning their work within the Scandinavian tradition, Holmegaard et al.'s (2012) own work on identity and choices focuses on two areas. These areas are that young people make free choices but with limitations and that their choice is an individual responsibility but one that is socially embedded. A young person's choice of what to study for Higher Education is exciting but there is an anxiety about making the 'right' choice. This choice is made from a combination of interests and that the subject chosen will lead to a fulfilling career. Young people want to choose something for themselves but they also want that choice to be meaningful for their family and friends. When looked at through this lens, choice becomes part of the identity work that young people participate in.

Choices linked to future careers

Woolnough (1994) proposed that choices were based on three factors – in school factors, out of school factors and personality. How teachers and teaching influence students' choices will be discussed later, as will personality or identity development. One of the out of school factors that is often quoted as influencing choice is the relevance of science or physics to a future career; similar to the utility value of science subjects identified in the Eccles et al. (1983) choice model.

Stewart (1998) carried out a small survey (128 students) of students who had already chosen to study A-level physics, looking at differences in attainment, attitude to and opinion of syllabus content. She found that girls who chose to study A-level physics tended to be higher attaining than boys, were mainly studying physics as an aid to entering a caring profession (e.g. medicine) and enjoyed physics being taught in context. Williams et al.'s (2003) work with year 10 students showed that for those who found physics boring this was not only because it was hard (see below) but also because they did not find the subject relevant to either themselves or for their future careers.

The students who participated in Pike and Dunne's (2011) interviews made it clear that their post 16 choices had been made based on their future educational and career pathways as well as their experience of secondary school pedagogies and the differentiation of subjects by difficulty. They were not willing to pursue a subject if it did not fit into their future educational and career pathway. Cleaves (2005) also found that the students she worked with made their future science choices linked to their knowledge of science careers.

The aspiration to pursue a career in science is often formed at an early age. The ASPIRES project (DeWitt et al., 2013) investigated the formation of future science aspirations in year 6 pupils in England. They found that girls, pupils of a mixed ethnicity and pupils with a low cultural capital had lower aspirations in science than other groups of pupils. The aspiration to pursue future study of science and a future career were closely linked to attitudes to school science, science self concept and parental attitudes. Research in the US by Tai et al. (2006) confirms that early aspirations are linked to future science study. They found that, if at the age of 13 a student expected to have a science career at the age of 30, they were 1.9 times more likely to get a life science degree and 3.4 times more likely to earn a physical science degree than those students who did not have the same aspirations.

In summary, intended career choice is often found to be a dominant factor in future subject choice. If a child has formed an aspiration to pursue a scientific career at an early age then they are more likely to choose to study the sciences later in their academic career than those who do not hold this early aspiration. Boe et al. (2011) found that amongst Norwegian students who chose to study physics, especially girls, many of them chose it for its perceived utility value; it was seen as a gatekeeper subject that was useful for many careers. However, only a small number of those who chose physics for this reason went on to study it at degree level. The majority of students who chose to study physics at university not only wanted a future career in the area but enjoyed the subject as well.

Influences of Teachers and Teaching

As pointed to above in research about why students do or do not choose to study science and/or physics post 16, another major factor identified is the influence that significant others, including teachers, have on that choice. It can be argued both that students choose to continue to study a subject if they have an interest in that subject (as outlined above) and that, in schools, it is the teachers who are the main people who will influence whether an interest in a subject is fostered or diminished. The teacher effects can be looked at from two directions – one the teaching techniques used in the lessons and secondly the personal interactions between teachers and pupils.

Osborne and Collins (2001) investigated pupils' views of the science curriculum. When pupils express their views about the science curriculum they also tend to express views about how aspects of that curriculum are taught. Osborne and Collins used focus groups to research pupils' views. They conducted 20 focus groups with 144 16 year olds. They chose to use focus groups, although these had not been used extensively in science education research in the past, to research insight into the experience, views and beliefs of pupils. They argued that data gathered from focus groups is often a more accurate reflection of individual views as opposed to data from an individual interview where the pupil being interviewed may tell a 'story' to please the interviewer.

The pupils said that their interest in science classes was maintained by teachers who made the lessons 'fun', either through their methods, or presentation of material, or through the organisation of work which immersed pupils in practical activities. Girls also identified those teachers who devoted time during a lesson to clarification of content, and those who built up a good relationship with their pupils by giving opportunities to raise questions and discuss aspects of science as those who maintained their interest. Weaker teachers were identified as those who relied on 'writing on the board' and text books.

In their 1989 study, Tobin, Deacon and Fraser (1989) used a case study approach to investigate an example of, what they identified as, exemplary physics teaching in a High School in Perth, Australia. They observed one teacher teaching his grade 11 physics class for 12 lessons and then interviewed selected students and the teacher about the observed lessons. Although this is a report of just one teacher and how he taught his physics class, it gives a good starting point for investigating what a good and effective physics class looks like and the activities that could be used to achieve this. Overall, four points were identified by these researchers as having an impact on the students' learning. These were:

1. the teacher's belief that students should be mentally active in order to learn with understanding
2. that the teacher used strategies to facilitate student understanding of physics concepts
3. that the external examination influenced the implementation of the curriculum
4. that the learning environment that prevailed in the teacher's physics class was viewed favourably by students.

(Tobin, Deacon and Fraser, 1989, p146-148)

No in-depth details are given of the specific teaching strategies used to facilitate student understanding as highlighted in point 2. The only indications of these are two comments that the teacher encouraged the students to work independently in small groups and that he used investigative experimental work.

Studies in European countries have also looked at the issue of physics teaching and physics teachers. These include work carried out in Norway by Angell et al. (2004) and in Switzerland by Ladubbe et al. (2000). In their study in Norway, Angell et al. (2004) investigated pupils' and teachers' views of physics and physics teaching. They used a combination of questionnaires and focus groups to gather their information. Their questionnaires were given to a random sample of grade 12 and 13 pupils studying physics (2192 pupils); to a random sample of all grade 12 pupils (1487); and to 342 physics teachers in upper secondary schools. The questionnaires contained a mixture of open and closed questions. Following on from the questionnaires, focus groups with selected grade 12 and 13 physics pupils were conducted. These focus groups were segmented according to gender to facilitate sharing of perceptions. Overall, they found that pupils found physics interesting but demanding, formalistic in nature, but still describing the world.

Girls had different demands from boys about what helped their understanding of physics; they emphasised context and connectedness. All pupils, but especially girls, liked studying topics such as relativity and astrophysics. In the actual classroom, all pupils indicated that they would like to see a stronger emphasis on qualitative or conceptual approaches (for example, discussions and demonstrations) and more student centered teaching (for example, using pupils' suggestions in the lessons, letting pupils choose problems and methods in experiments, group problem solving, project work). They also indicated that variety was essential for good teaching. Although there was not much difference between girls and boys in this research, girls did show a higher preference for all of the above and also 'cookbook' experimentation. These results came mainly from the questionnaires with the focus groups being used as a triangulation method. No details of the descriptions given to explain the questionnaire answers were given.

In Switzerland, Ladubbe et al. (2000) carried out a quasi-experimental study looking at both teaching strategies and teacher behaviour in physics. Their study was with students in upper secondary schools who were all taught by teachers with Masters degrees in physics, mathematics or science but only basic education qualifications. They chose a positivist approach to their study as they felt this would be most acceptable to teachers trained in the physical sciences. The core of their investigation was a range of classroom interventions and involved 25 teachers and about 600 students. The quasi-experimental approach consisted of four groupings of teachers and their classes:

Group 1	full involvement with training and development of materials for teachers
Group 2	use of materials and training for teachers
Group 3	use of materials but no training for teachers
Group 4	control

To test the interventions, they did a preliminary survey with all the students, gave tests at the end of the topic units covered by the intervention and gave all students and teachers a final survey. Overall, they found that girls' attitudes to physics could be improved by a collection of teaching strategies. The most effective were integration of individual preconceptions, student-orientation, physics as an experience, student discussion and using everyday physics as examples. They also looked at teacher-pupil interaction. Their results indicate that a physics teacher has a key role to play in all students' attitudes and achievements in physics, not just for girls. They found that there was some evidence from teacher questionnaires and interviews that during training for the implementation of the classroom interventions, teachers increased their knowledge of and sensitivity to gender issues. These came into play when implementing the teaching strategies involved in the interventions.

Much of the early research about teacher-student interactions has been focused on the time spent by the teacher with each student. In a meta analysis of research about the time teachers spent with students in all subjects, Kelly (1988) found that, on average, teachers spent 44% of their time with girls and 56% with boys with the biggest differences in time being observed in science and social science subjects. However, it is not just the time that a teacher spends with a pupil that can influence how they feel about a subject but the more personal interactions that take place both inside and outside of the classroom.

In 2005 Krogh and Thomsen (2005) reported on part of a large, longitudinal study of physics in the Danish upper secondary school system. They reported on phase 2 of the study where 789 students were selected to complete a questionnaire on 'Possible influences in students' attitudes towards physics and choice of A-level physics'. The survey was given when students had just decided which subjects they would take for A-level. 45 of these students were interviewed, using semi-structured interviews, to collect supporting evidence. Their study showed that students would like their teachers to take more interest in them as persons, for example, by using less transactional communication styles and simply by being more off task in the classroom.

The relationship between students' attitudes to science and teachers taking an interest in them as persons is also reported in Wubbels and Brekelmans (1997). Wubbels, Creton and Hooymayers (1985 cited in Wubbels and Levy, 1993) developed a model to map teacher interpersonal behaviour based on a model used in clinical psychology and psychotherapy, originally developed by Leary in 1957. This model has eight different behavioural aspects: leadership, helpful/friendly, understanding, student responsibility and freedom, uncertain, dissatisfied, admonishing and strict. An instrument to measure students' and teachers' perceptions of interpersonal teacher behaviour was developed by Wubbels and Levy (1993) based on extensive interviews with students about their perceptions of the teacher. This instrument gives scores for each of the eight teacher behaviours based on responses to questions, using a five point scale. Wubbels and Levy report that for classes to be effective they should become more student centred, that teachers should give their students more responsibility and act in an understanding way.

Fisher and Rickards (1998) used the same model and a very similar questionnaire to investigate teacher-student interpersonal behaviour and student attitude to mathematics in Australia (21 teachers in 9 schools and 405 students in grades 8, 9 and 10). Student attitudes to mathematics tended to be higher in classrooms where the students perceived greater leadership and helpful/friendly behaviour in their teachers. A better attitude to the subject is seen as an indication that students will be more willing to continue to study the subject post 16 (see section on choices). Fisher and Rickards feel that the assessment of interpersonal behaviours could be as important as teacher personality traits and teaching style in describing an effective mathematics teacher. Further research using the model and questionnaire was conducted by Levy et al. in 2003. They carried out a survey of 3023 students and 74 teachers in 168 classes in 7 secondary schools in Washington DC. They found that 10% of the variance in student perception of teachers could be explained by student and teacher gender and ethnicity, student age, class size, the subject taught and the experience of the teacher. More research is needed into these areas, specifically in physics, if more is to be understood of the complex and interactive nature of students' perceptions of teachers and the learning environment.

In summary, the body of research reviewed in this section demonstrates how important a teacher and their teaching can be in influencing a pupil's attitude towards their subject and their future choice as to whether to study that subject or not. Pupils report that they enjoy lessons that are fun and where they carry out a variety of activities that are student focused including opportunities to discuss the subject content. Pupils appreciate it when teachers take time to clarify the content which allows them to understand the concepts being presented. Pupils report that their best teachers are the ones who build up a good relationship with their pupils and are interested in their pupils as people. It is with these teachers and in these lessons that pupils find an enjoyment of the subject and decide whether or not to pursue that subject further.

Additionally, it is not only individual teachers but the whole school ethos that can influence the uptake of subjects post-16. Reporting on their study into post 16 physics and chemistry uptake, Bennett and her co workers (Hampden-Thompson, Lubben and Bennett, 2011 and Bennett, Lubben and Hampden-Thompson, 2013) describe the factors they found at schools where uptake was the highest. They found the highest uptake at schools where there was a positive school ethos towards physics and chemistry, where there was stable management, where there was a diverse GCSE offer, where there were specialist physics teachers, where exam grades necessary for progression were at grade B or above, which offered subject specific careers advice, structured work experience and extra curriculum career experiences, and where pupils were encouraged to be ambitious and empowered. However, they did not take account of the socioeconomic make up of the schools or the ethnicity of the pupils which could have influence on how the school ethos developed.

Influences of Others

Moving away from teachers and to other significant people, Sjaastad (2011) reported from his work with 5077 Norwegian undergraduates that parental influence was reported by 22% of respondents as having played a role in their subject choice. Work in the US by Tenenbaum and Leaper (2003) and Bhanot and Jovanovic (2009) investigated the links between parental behaviours and beliefs and children's science interests and abilities. Looking at conversation within the family, Tenenbaum and Leaper found that parents of daughters believed that their child was less interested in science than parents of boys and that science was more difficult for girls than boys. These beliefs were found to predict the children's interest in science since the parents transmitted these beliefs to their children. Bhanot and Jovanovic (2009) found that parents of boys believed that they had a higher ability in science and that science was more important for them in the long run. For girls, it was mothers who had the greatest influence on their daughters. Girls were found to have a more positive attitude to science when they had discussions with their mothers about the important of science.

The influence of family on the decision to become scientists was also observed by Gilbert and Calvert (2003) in their work in New Zealand. The five women scientists whom they interviewed all reported that their mothers had influenced their choice to study science. Most of them also commented that they wanted to be like their fathers but also to have a fuller role within their family as their mothers did.

The influence of peers must not be forgotten. Stake and Nickens (2005) reported that girls tended to have less peer support for their science interests than did boys. In their work with 161 female and 163 'gifted' US high school students who took part in a science summer programme they found that students who reported having positive science peer relationships were associated with more positive images of themselves as scientists.

A recent wide scale project looking at participation in mathematics and physics (UPMAP – Understanding Participation in Mathematics and Physics) has started to report findings from both its quantitative and qualitative strands. Although the project investigated attitudes to and choices about these two subjects together, the large research base allows findings to be reported separately for each subject. Reporting on one of the qualitative strands of the UPMAP project, Rodd, Reiss and Mujtaba (2012) found that physics undergraduates reported that they had come to physics because of a relationship with key people in their past. Rodd, Reiss and Mujtaba speculate that this may be different from those who choose humanities. They suggest that in, for example, English, students develop a deep involvement with their favourite literary characters. These characters become part of them and the students start to think and feel as these characters would. In physics, it is actual people, not fictional characters that form these relationships.

In summary, the research shows that parents, peers and other adults can all be significant in influencing pupils' future subject choices. For girls, the evidence shows that mothers can be particularly significant.

The Image of Physics

When pupils are asked to describe a physicist, or a scientist, the general response has been that they are a White, middle class male. When asked to talk about the subject physics, the response has been that it is a masculine subject that is hard. These are the commonly held, stereotypical views of science and scientists and in particular physics and physicists. Ryan (2011) calls these views 'commonsense' ideas about subjects that produce and reproduce the gendered understandings about what is appropriate and natural for male and female interests and subject choices.

For many years, the physical sciences and mathematics have been perceived as being masculine and the arts as being feminine. This is clearly described as a binary dichotomy by Francis (2000) e.g.

male	female
rationality	emotion
objectivity	subjectivity
science	nature
hard	soft
the sciences	the arts

These ideas about what is 'natural' for boys and girls are formed at an early age. In one paper from the recent ASPIRES project, Archer et al. (2013) looked at primary school girls and their parents' constructions of science aspirations. These results were from phase one of the project where 9319 year 6 pupils (50.6% boys and 49.3% girls) across England were surveyed. Supporting evidence came from 170 interviews with 78 parents and 92 pupils from 11 schools. Their results showed that girls constructed science careers as masculine and incompatible with their performances of popular femininity. This meant that they found science aspirations unthinkable. These perceptions were exacerbated by social class with working class girls having the most negative constructions.

Stereotypical views are linked to images of self. Breakwell et al. (2003) found in their study of 1140 UK 11-16 year olds (570 boys and 570 girls) that the reported image of a girl who liked science was of one that was less feminine than 'normal'. The notion that liking science and/or physics is less similar to most young people's self image is also the basis for the work in Germany and Holland by Hannover and Kessles (2004), Kessels et al. (2006) and Taconis and Kessels (2009). Hannover and Kessels (2004) reported that science and mathematics students were matched with the least-liked subject prototypical student for the majority of 8^{th} and 9^{th} grade German students. Students did not relate to physics and mathematics students because they thought they (physics and mathematics students) were less physically and socially attractive, more isolated, less creative and less emotional than them. Kessels et al. (2006) looked specifically at the image of physics. They found that 63 German 11th grade students associated physics (compared with English) as difficult, for males and heteronomous. The attitudes amongst those students who had dropped the study of physics, as expected, was more negative than those who were still studying it. Girls also held a more negative view of physics than boys. Taconis and Kessels (2009) study of 54 Dutch 9th grade students confirmed the views of science and physics held by students in other countries. They also found typical peers who liked science as less attractive, less popular, less creative, less emotional, more intelligent and more motivated than peers who favoured the humanities.

Research in the US by Baker and Leary (2003) also found that issues of stereotypes played a role in girls' subject choices. They carried out a small scale qualitative project asking girls at various stages of their schooling career to tell them about their feelings about science. These girls all volunteered to take part in the project. These girls were confident in their ability to be successful at science. However, even though they disagreed with the idea that girls cannot do science or be scientists they also made stereotypical negative statements about girls and science especially about physical sciences.

Changing stereotypical views of scientists by using role models has been suggested as a possible method for encouraging more girls to study science. Buck et al. (2007) investigated how a small group of 13 girls in the US and 8 women science graduates who had volunteered for a school outreach programme came to decide what made a good role model. The girls felt that a good role model was someone they could feel a deep connection with and that these usually came from within the family. They did not initially see scientists as role models (they felt they were 'too geeky') and it was not until they had got to know the women scientists that they started to relate to them. The issue of the gender of the role model varied from girl to girl, but they all agreed that whatever the gender they needed to personally connect with the scientist for it to make a difference. The women acting as role models felt that gender matching was important. They initially thought that the role model was there just to help the students like science but came to realise over the time of the intervention that this would only happen when personal interactions took place as well.

Recent work by Betz and Sekaquaptewa (2012), also in the US, has found that female STEM role models can in fact demotivate middle school girls. This is because women who work in STEM can be seen as impossibly successful especially for girls who are already uninterested in science at this age. These women are perceived as having less feminine traits than normal, and for uninterested girls this possible future self is so far removed from their present self that they feel threatened rather than motivated.

The work of Cleaves (2005) also focused on stereotypical views of science students but linked the views of individual students with the stereotypical images of others. She found that not all students who went on to study science could be classed as stereotypical science students i.e. those who had committed to science from an early age. Other students who chose science had not made the decision to study science at such an early age and held less committed views on what to study. Their choices were influenced by their self perception of science and their knowledge of science careers.

Ong's (2005) work with young women of colour who were working in the physics department of a large US research university found that they tried to overcome the gender stereotypes expected of them by the act of fragmentation. This meant that they displayed, or performed, White and masculine traits so that they would be accepted in the workplace. This performance of different identities (see Chapter 3) in order to survive in the science workplace was also observed by Gilbert and Calvert (2003) with their work with female scientists in New Zealand.

Work in the ASPIRES project also looked at how the stereotypical view of scientists influenced children's engagement with it. Wong (2012) studied two 13 year old British Asian girls who could be classified as high achieving. One of these girls, who was in the top set for science and wanted to study the three separate sciences at GCSE and then move on to a possible science career, did not show any particular interest in the subjects but saw them as allowing others to see her as clever and smart. The other, who was also in the top set, did not like science, hated physics and was more interested in her looks than being recognised as being smart. Another strand of the ASPIRES project looked at parents' and primary children's constructions of who engaged with science (DeWitt, Archer and Osborne, 2013). They found that about half of the interviewed parents described scientists in a stereotypical manner, that of being a 'geek' or a 'nerd'. Few of the children however agreed with this image. Over half of the children described scientists as being clever and thought that their science-keen peers fell into this category. The remaining children saw scientists as normal, but very few parents described scientists in this way. Further analysis of the children's interviews (Archer et al., 2012) found that of those girls who did identify with science at the age of 10/11 they were already having to balance their science aspirations with performance of popular heterofemininity to make those identities 'thinkable'.

As identified above, one often quoted belief about physics is that it is a hard subject. Lyons (2006) identified this as one of the themes that emerged from reviews looking at attitudes to science (the others being the transmissive pedagogy of school science and the personal irrelevance of science curriculum content to pupils). Physics was perceived as being the most difficult science followed by chemistry and then biology.

Students in Bennett and Hogarth's work (2009) showed a marked reluctance to study physics because it was perceived as hard. The work of Pike and Dunne (2011) looked at this discourse of hardness. They recognised the paucity of research using a more exploratory approach for investigating choice so carried out a mixture of one to one and focus group interviews with students who had just made their post 16 choices. They found that there was a dominant discourse of subject differentiation into a hierarchy of difficulty with science and mathematics being seen as hard subjects. They also found that students positioned themselves as being capable or not capable of further studies of these subjects.

A small scale survey research project by Williams et al. (2003) carried out with 317 year 10 (aged 14-15) students, found that one of the reasons that students found physics boring was because they found it difficult. A study by Stokking

(2000) carried out in Holland found similar results. He carried out surveys with 1371 students over a two year period. Overall his results showed, amongst other results, that female students scored significantly higher on their perception of physics difficulty. This was one reason why female students less often chose to study physics later in their secondary school career.

Students who like a 'hard' subject such as physics are also perceived to be less popular and less socially acceptable than their peers. Francis et al. (2010) investigated how some high achieving pupils also managed to be popular with their peers. Popularity is a complex and slippery concept. Popularity does not always mean the most liked as it also contains aspects of influence and sources of admiration and someone who is popular with one group may not be with another. However, popularity is a concept that is recognised in schools. Francis et al. looked at 71 high achieving year 8 pupils in nine schools in southern England. Of these 71 Francis et al. found a sub group of 22 pupils that were both high achieving and popular as identified by other pupils on a survey. These high achieving popular pupils were generally good looking, fashionable and sociable. These pupils produced both normative performances of gender but also dialogic performances containing aspects usually associated with the other gender. For example, boys could be seen to be engaged in the classroom by working hard and completing classrooms tasks (normally associated with girls) and girls as being assertive and confident (normally associated with boys).

These dialogic performances of gender, performances that include aspects usually associated in a binary dichotomy with the other gender, have been used to discuss how girls come to choose subjects especially where there is a tension between how they see themselves and in doing subjects that are considered masculine. Mendick (2003 and 2006) used the term 'female masculinity' to describe girls who chose to study A-level mathematics. Francis (2010) describes gender as monoglossic and heteroglossic. The monoglossic interpretation of gender is that based on a binary where the male is masculine, objective, strong and active and the female is feminine, emotional, weak and passive. Heteroglossia exists within the monoglossic system and describes micro level contradictory productions of gender. Francis argues that the terminology female masculinity can only be applied to a small number of girls who display many male attributes whereas heteroglossia can be used to describe many more behaviours where girls have a macro femininity but micro masculine contradictions as seen in her study of high achieving pupils described above.

This section on the image of physics describes how the generally held view of physics is that it is a subject studied by White, middle class, males, that is hard and boring. This perception of physics is formed during early childhood and girls report that the image of physics and physicists is not compatible with their self image. They see girls who like physics as being less feminine than them. It has been found that female role models can help to change this image, but only when personal interactions take place, otherwise girls see female physicists as being too different from themselves to be an identity that is achievable. Women working as physicists often report that they perform 'as expected' in the workplace. They display more masculine traits in order to be accepted.

Conclusion

The research discussed in this chapter indicates that young people's overall attitudes to science is generally not positive (Simon and Collins, 2003 and Jenkins and Nelson, 2005) with girls being less positive than boys (Bennett and Hogarth, 2009). Attitudes towards science change most in secondary schooling (Reiss, 2004) with the decrease in liking for physics being more pronounced than for biology (Spaull et al., 2003 and 2004).

Choices as to which subjects to study after compulsory schooling are influenced by future careers, teachers and teaching and significant others. Future career choice is often a major influencer of subject choice (Woolnough 1994, Pike and Dunne, 2011 and Cleaves, 2005) with early formed career aspirations in science often leading to persistence of choice (Tai et al., 2006). The literature reports that good teaching leads to enjoyment of the subject which often leads to associated subject choice. Examples of this specifically for physics can be found in Tobin, Deacon and Fraser, 1989, Angell et al., 2004 and Ladubbe et al., 2000. The teachers themselves and how they interact with the students in their classes also influence choice with good personal interactions leading to a more positive attitude in students (Krogh and Thomsen, 2005 and Fisher and Richards, 1998). For all students parental influence is important when considering future choices (Sjaastad, 2011) and for girls, the mothers' influence is particularly important (Gilbert and Calvert, 2003).

One particular issue for the choice as to whether to study physics further is the stereotypical held view that physics is hard. Since physics is perceived as being hard, many students are reluctant to study it (Bennett and Hogarth, 2009 and Pike and Dunne, 2011). Girls who like physics are perceived by others as being less feminine (Breakwell et al, 2003 and Cleaves, 2005). This image of physics is experienced as a less attractive image than for many other careers and does not match with the self image of many girls (Hannover and Kessels, 2004). Girls who do like physics and science and remain popular with their peers are generally good looking, fashionable, and sociable and perform both normative performances of gender but also dialogic, non-normative performances (Francis et al., 2010).

As can be seen, the question 'why choose physics' is a complex one that involves many interrelated issues. The research shows that the main influencers of choice are subject enjoyment, usefulness of the subject (for example to future career or self), the influences of significant others including teachers and prior achievement which are all linked to identification with the subject. Included in this identification with physics are self concept/self efficacy and the image of physics that points to the stereotypical view that physics is a hard subject that only White males can do. These views of physics are formed early in life (Archer et al., 2013).

Murphy and Whitelegg (2006a) identified a key determinant as to whether girls choose to study physics post 16 is 'how students saw themselves in relation to the subject, both now and in the future; their physics self concept' (piii). How girls see themselves in relationship to physics can also be called their identification with physics. Brotman and Moore (2008), when looking at the underlying concepts of science education research, identified that a focus on identity was becoming more prevalent. Even though identity has been identified as a focus for recent research in science education, this is still a developing area, especially in the UK. Research about what a science identity is and how it develops has been carried out mainly in North America. Research relating science identity to choice is limited.

Many of the topics outlined in this chapter contribute to one's identity development. For example, girls do not see themselves as a 'physics type of person' because this is contrary to the image of physics that is held by many in society. A poor attitude to science can develop because science is seen as a hard subject to which only a privileged few can aspire. A lack of a positive attitude to physics and a feeling that it is not for them leads to a choice not to study the subject when it becomes non compulsory. Rather than looking at these in isolation, bringing them together in a study of science/physics identity development and how this impacts on choice could give a more holistic view of how young people decide on their futures.

Much of the research into subject choices, attitudes to science and the image of physics has been done using quantitative methods but it has been recognised, as identity and self concept/self efficacy become more important factors to investigate, that qualitative methods may result in more detailed knowledge about choices. Qualitative research can give a thick description of why young people are making the choices that they are, why they have a certain attitude towards science and physics and why they see physics in a certain way. This move towards adopting qualitative research methods when investigating choice has influenced my research design that is discussed in Chapter 4.

Chapter 3 A Developing Framework for Identity and Self Efficacy

Introduction

In this chapter I develop a framework for identity and self efficacy that I use to investigate girls' physics choices. Previous researchers looking at science identity have described it as 'who we think we must be to engage in science' (Calabrese Barton, 1998, p380). This description involves considering broadly who students are and why they choose, consciously or subconsciously, to engage or disengage with science in a classroom setting (Shanahan, 2009). However it is often the case that in the literature focused on gender and science the conceptions of identity and, to some extent, self efficacy are under theorised.

I start the chapter by presenting a theoretical position on identity drawing on the theoretical perspectives proposed by Jenkins (2008) and Gee (2000). Once this working description of identity is presented, I draw on the theoretical discussions of communities of practice (Lave and Wenger, 1991) and figured worlds (Holland et al., 1998) to develop a position on where and how science, and in particular, physics identities are developed. Both communities of practice and figured world theories have been used in the literature to describe girls' relationships with science and physics. In this chapter I interrogate this literature base and discuss outcomes from it that can help us to understand how girls come to make their choices about whether or not to study physics post 16.

Traditionally self efficacy and identity have been investigated separately. Identity research in education is mainly from a sociological and qualitative perspective whereas self efficacy research is predominantly psychological and quantitative. Originally my research focused on identity and self efficacy as two stand alone constructs. As I developed my thinking and understanding about the two topics, I came to view self efficacy as one component of identity and that the two needed to be investigated as such. Following the discussion of figured worlds in science identity literature, I briefly introduce self efficacy and some of the relevant literature before suggesting how the two can be linked by closing the chapter with a look at how narrative has been used in identity and self efficacy research and how this informed my methodological choices.

Developing a Framework for Identity

Researchers in many fields have used identity as a basis for investigating society. However, the term identity has taken on a range of meanings in this literature, including in the education arena. In this introductory section, before I interrogate the literature about "science identity" specifically, I describe how I came to the description of identity that I will use in my research.

I drew on four theoretical perspectives on identity in order to develop the perspective on identity used to analyse the data gathered on girls' relationships with physics and their subsequent choices. The first two of these four theoretical perspectives are those proposed by Jenkins (2008) and Gee (2000) and are used to develop my understanding of identity whereas the second two proposed by Lave and Wenger (1991) and Holland et al. (1998) provide a way of describing how we come to that identity.

What is identity?

Jenkins (2008) proposes that

> identity is the human capacity to know who's who. This involves knowing who we are, knowing who others are, them knowing who we are, us knowing who they think we are and so on. Identity is a process (identification) not a thing. It is not something that one can have or have not, it is something that one does. (p5)

This description of identity involves both self and collective components. Jenkins further argues that these cannot stand alone. The work of identity, identification, is

> the systematic establishment and signification, between individuals, between collectives, and between individuals and collectives, of relationships of similarity and difference. (p18)

Proposing this theory, Jenkins goes on to argue that the identity of any individual is not meaningful if isolated from the rest of the world and from other humans. We cannot "do identity" in a social vacuum. Each individual is unique, but this uniqueness is socially constructed. Individual identity formed at an early age (for example, kinship, ethnicity) is likely to be less changeable than that formed later in life although change is fundamental to identification.

All identities are constituted through the process of 'the internal – external dialectic of identification' (p40). This means that with our identity work, what others think of us is as important as what we think of ourselves. When we send out signals about who we are, it is, in part, how those signals are interpreted by others that gives us our identification. The problem is that we cannot control what others think of those signals nor how they interpret them. This can result in differences between how we see ourselves and how others see us even though both of these contribute to who we understand ourselves to be.

Jenkins description of identity as a combination of both self and collective resonates with my own thoughts on how we come to be the type of person (or persons) that we are, dependent on the context we are in. His use of the term "know" in his first description of identity perhaps goes too far – do we ever really know who we are, know who others are or know who they think we are? This would perhaps be better described in terms of thinking we know who we are and so on.

The second perspective on identity is from Gee (2000). Gee describes identity as 'the kind of person (you are) in a given context' (p99). This perspective means that people can have multiple identities connected to how they perform in society. Gee offers four ways with which to view what it means to be a certain kind of person: nature identity, institution identity, discourse identity and affinity identity. The identity of each kind of person is viewed in terms of where that identity comes from, who has the power to identify it and who has the power to maintain it.

At the heart of this identity theory is the idea that individuals are recognised by others as a specific kind of person. An individual needs to be seen by others in certain ways for their identity to be recognised. This can only happen if there are people who can recognise certain identity traits in certain ways. This interpretive system can be historical and/or cultural; the rules of an institution; discourse between people; or the working of an affinity group (a group where members have allegiance to, have access to and participate in specific practices that lead to the formation of a group with recognisable common bonds).

Gee's description of identity depends very much on the interpretation of an individual by others. Gee does acknowledge that we may have a 'core identity' but does not discuss how this could be integrated with the notion of 'how others see us'. His theory relies on others having the knowledge to see you as a certain type of person but how this knowledge is developed within a historical context, an institution, in discourse or by an affinity group is not discussed.

Combining aspects of these two theories brings me to a working description of identity. I use 'identity' to mean the process of coming to think we know who we are, thinking we know who others are, them thinking they know who we are, us thinking we know who they think we are and so on. This is not something we have but something we work towards throughout our lives. We work towards our identity (through doing identification[8] work) by establishing and looking at the signification between individuals, between collectives, and between individuals and collectives and looking at relationships of similarity and difference. Whilst doing this identification work we view ourselves and others as certain kinds of

[8] Identification is the process of coming to identity.

persons. We recognise ourselves and others to be a certain kind of person within a given context.

In the science identity literature described later in this chapter, as I stated above, a range of descriptions of identity are used. One body of work that I have not drawn on is that using a model of science identity initially proposed by Carlone and Johnson (2007). Although they use Gee's ideas about the kind of person you are to underpin their proposed model of science identity, Carlone and Johnson (2007) go on to describe science identity as something that you have. This model and modifications of it have been used by Johnson et al. (2011) to study science identity with women of colour; by Carlone et al. (2011) and Carlone (2012) to study the normative scientific practices of a US fourth grade science classroom; by Kane (2012a and 2012b) working with third grade African American children; and by Hazari et al. (2010) to quantify the physics identity of US high school pupils. Whilst I acknowledge that some of the outcomes from this approach could inform us about what can influence a person's developing identification with science and physics, similarly to the research described in Chapter 2, it cannot inform us what a science identity is if we understand identity as something that we work towards, not something that is fixed and that we have.

Communities of Practice

Lave and Wenger explain that the concept of community is crucial to their theory of situated learning (1991). They say

> a community of practice is a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice. (p98)

Drawing on their perspective would involve the science classroom being viewed as a community of practice and learning in that classroom being viewed as an activity where new members are inducted into that community of practice. Lave and Wenger explain that when a newcomer enters a community of practice they start from a position of legitimate peripherality. This involves participation as a way of learning the practices involved in that community. Continuing involvement provides an opportunity for the learner to make the culture of practice in that community theirs. The newcomer can then move towards membership of the community where its members participate at multiple levels due to their different interests, diverse contributions and varied views of the community.

Communities of practice in science education literature

The communities of practice framework has been used extensively in the science identity literature (for example Brickhouse, Lowery and Shultz, 2000; Brickhouse and Potter, 2001; Tan and Calabrese Barton, 2007, 2008; Danielsson, 2012), which will be discussed below. Much of this work on science identity was carried out in the USA in both middle and high schools (Brickhouse, Lowery and Shultz, 2000; Brickhouse and Potter, 2001; Olitsky, 2006). These schools were mainly in urban, poor areas with a high percentage of African American and Hispanic students.

Brickhouse, Lowery and Shultz (2000) investigated 'What kind of girl does science?' They followed twelve 7th grade girls at a US East Coast Middle School over 18 months. Their study was ethnographic in nature (classroom observation and interviews) and also included asking the girls to keep journals. They found that one of the issues with science education is that teachers are trying to enculture students into what they believe is the science community of practice (namely research scientists) but that this is too far distant from the majority of students' understanding of what being a scientist is. They found that girls who more closely conformed to their view of scientists were responded to more positively by the teacher. The two girls from this research who were identified as fitting this pattern were one who was a good student overall academically but who was not particularly interested in science (i.e. an "academic") and one who was only an average student academically but who used her social skills to engage with the class. Girls who had a stronger identification with science as a subject but who did not conform to what a teacher thought was a scientist were not encouraged by the teacher. Two examples of this type were one girl who enjoyed figuring things out but was not "academic" and one who was loud in class.

Brickhouse and Potter (2001) carried out a longitudinal, ethnographically based, study of ethnic minority girls in an urban setting. They collected data over three years, starting in the 7^{th} grade. They found that girls in their study experienced both marginalisation and participation in school communities of science depending on their social and personal identities (i.e. their gender, ethnicity, socio-economic background, peer relationships). This is an example of how the various communities that are found in a school interact and how individuals may be constrained by structure and power that limit the communities of which they can be part.

Olitsky (2006) investigated how discourse is part of a community of practice and how the discourse used in the science classroom can also influence the development of a student's identity. The commonly held discourse that portrays science as 'too hard' conveys the idea that only a special type of person can have an identification with science. The discourse in a science classroom however is not the only discourse that contributes to identity formation. It is also the discourses used by peer groups, the school system, the neighbourhood in which students live and, of course, the teachers. Olitsky's research was part of a study of five schools in Philadelphia looking at science education in an urban setting. She carried out classroom observations, student interviews and used students as researchers. She found that students here were more likely to identify with science if they were part of the social groupings that were college bound or had a social background (for example, higher socio economic level or parents who were scientists) where they were more familiar with the language of science. This evidence suggests that again it is the social and personal identities of students that have strong influences on the development of science identities.

How identities and participation in communities of practice can be used to explain persistence or not in the 'science pipeline'[9] was described by Aschbachter, Li and Roth (2010). Using a sample of 33 high school students, who in the tenth grade all expressed an interest in pursuing a STEM course or career, they explored why some, by the time they reached the twelfth grade, persisted in this and why others changed their minds. They identified three groups who they termed Lost Potentials, High Achieving Persisters and Low Achieving Persisters.

Twenty five of the students were described as Lost Potentials. These were students who described a poor experience of science at school due to poor instruction and a lacklustre curriculum. They now found science hard and described it as only for certain people. They now thought that science careers were difficult to attain and more effort was needed to be successful in these types of career. These students now found other subjects more interesting than science. They also reported that their families' encouragement to engage with science had changed to being more negative. The remaining eighteen of the students could be termed as Persistors, but they could be split into two groups: twelve were further described as High Achievers and six as Low Achievers. The High Achieving Persistors were students who gained good grades in science classes, aspired to 'high ranking' professions and acknowledged that science could be hard, boring and time consuming even though they wanted to continue to study it. The Low Achieving Persistors demonstrated a disconnect between their aspirations and levels of science attainment but were still interested in choosing science careers. They described more negative school experiences of science. In general, they came from lower class families, with fewer family members as science role models and received less science specific support than their High Achieving Persistor peers.

Members of these different groups experienced different interactions with the science communities of practice both in and outside school and within the extended family. The groups each experienced different micro climates within

[9] See Chapter 2

each of these communities of practice. Students who found support for science in multiple communities were more likely to consolidate their identification with science and persist in their STEM aspirations that those who did not. These were those students described as the High Achieving Persistors. Lost Potential students found little or no support for their developing science identities in the communities they were members of and so left the science pipeline.

Danielsson (2012) used communities of practice to investigate women university students who were studying physics in a Swedish university. As she says, 'the voices of women who have chosen to study physics are seldom heard' (p25). Using evidence from semi-structured interviews with five women, she identified three typical ways that women interacted with the physicist community of practice. Firstly there were two women for whom the relationship between gender and participation in the physicist community was central. One woman felt that she was a non-participant in traditional femininity and that was how she could be part of this community whereas the other did not see herself as being fully part of the community and due to her gender played a more passive role in the community. Two women felt that gender was not an issue with being a member of the physicist community as physics was gender neutral. Their participation in the community was due to the work they had done to achieve qualifications and autonomy in the laboratory. Finally one woman did not see herself as a traditional physicist but as an experimental physicist who enjoyed 'playing around with equipment until it worked' (p35).

In summary, the outcomes from science identity research using communities of practice as the theoretical framework to understand identity has shown that there is a cultural view, repeated by teachers in the classroom, of who makes a good scientist. This is someone who is typically described as a 'good student', but is not necessarily one who has an identification with science as a subject. The discourse used in the science classroom as well as the gender, the ethnicity and the socio economic background of the students are all found to impact on their developing science identities. Students in the 'science pipeline' could be described as either Persistors or Lost Potentials depending on how they participated with the science community of practice. Women who had already chosen to study physics at university could also be described as being members of one of three types, again depending on how they interacted with the science community of practice.

Criticisms of communities of practice theory

One of the criticisms of the use of communities of practice in education is the question: what community of practice are the students entering? Lave and Wenger (1991) themselves discuss this.

> For example, in most high schools there is a group of students engaged over a substantial period of time in learning physics. What community of practice is in the process of reproduction? Possibly the students participate only in the reproduction of high school itself. But assuming that the practice of physics is also being reproduced in some form, there are vast differences between the ways high school physics students participate in and give meaning to their activity and the way professional physicists do. The actual reproducing community of practice, within which school children learn about physics, is not the community of physicists but the community of schooled adults. (p99)

We need to be aware of what we are trying to achieve in a school physics classroom. From my own experience of teaching chemistry, I would agree with Lave and Wenger that we are not introducing students to the community of practice of professional chemists (either industrial or academic). We are introducing students to an understanding of the subject. This may in future encourage some of them to move into the community of the chemist; or to use their knowledge of chemistry to embrace other scientific communities of practice; or to become a member of the scientifically literate community who do not further their study of chemistry but understand the importance of it.

The issue of the use of communities of practice to describe mathematics classrooms was discussed by Boylan (2010). In communities of practice, newcomers participate from a legitimate peripheral position until they become members of the community. They learn about the community from old timers. However, learning in a school classroom is modelled as individual acquisition of knowledge rather that social participation and this learning is frequently not contextualised. In the, often, transmissive pedagogy that is found in school classrooms, teachers and students do not learn along side each other. The teacher is expected to 'already have the knowledge' (p10). Also, the teachers are not teaching the students to become the same as them (teachers) as would be the case in apprentice learning that forms the examples used in communities of practice theory.

My working theory of identity, based on Jenkins and Gee, is a process whereby we come to think we know who we are as we, and others, come to see ourselves as a certain kind of person. We develop within many communities of practice but the majority of them do not operate where we engage with them as apprentices in order to become old timers. I needed a different way of describing the places where our identities develop. In science identity literature, the use of figured worlds has come to the fore, and I looked there for an alternative.

Figured worlds (Holland et al., 1998) offer a more flexible way of describing the various socially constructed collectives that we live in than communities of practice, and so I feel that they describe the places where our identities develop, and the spaces that are available for identity development in a classroom, in a more understandable way. Figured worlds are like communities of practice in that they do have a historical dimension, they do have social postionality where participants' positions matter, they are socially organised and they do develop over time; but they are not primarily focused on experts introducing new members into the workings of that community. This offers a different way to look at the physics classroom, one that will be described below.

Figured Worlds

Holland et al. (1998) describe identity as a combination of the personal world with the collective/social world; as a social product; as living in and developing in social practice; and as developing over a lifetime (p5). Their ideas of identity are based on work by Vygotsky and Bakhtin who view humans as social and cultural creatures who can move to form a set of socially and culturally formed subjectives by using human agency. Holland et al. develop these ideas to focus on the development of identity and agency specific to practice and activities in 'worlds'. Holland et al. call these worlds 'figured worlds'. The theoretical background of figured worlds is that they are a historical phenomenon; they are social encounters where participants' positions matter; they are socially organised and reproduced; and distribute 'us' across different fields of activity (p41).

The formation of figured worlds rests upon our ability to form worlds and be formed in collectively realised 'as if' realms. These worlds take shape and grant shape to the co-production of activities, discourses, performances and artefacts. Within these figured worlds are figures, characters and types who carry out its tasks, interact with it and each other and develop it. For figured worlds to exist they need to be both socially generated and culturally constructed. We can recognise figured worlds because we recognise particular characters, acts and worlds as being part of a given world. People within these worlds recognise particular outcomes over others. These worlds are formed and re-formed in relation to their participants' everyday needs. An example would be that we, and students, can describe and reproduce a 'normal physics classroom'.

For Holland et al. identities are formed in the process of participating in the activities that are organised by figured worlds. When we interact with a figured world it can be at many different levels; from fully embracing the world, to rejecting the world, to many different degrees of interaction with the world. Whatever level of engagement we end up having with a particular world, our identity is affected by it. In our everyday life we will encounter many different figured worlds; those that we fully engage with, those that we reject and those where we are still developing our identities.

Figured worlds in science education literature

Tan and Calabrese Barton (2007, 2008, 2009a and 2009b) use both communities of practice and figured worlds to describe their findings. They say that communities of practice can be thought of as figured worlds and that the classroom is a community of practice so therefore a figured world. However, they do not discuss any differences between how communities of practice or figured worlds are established.

Tan and Calabrese Barton studied girls in a US Middle School. They carried out an ethnographic study of a grade 6 science class which included thrice weekly lesson observations, two individual and group interviews, informal conversations and observation of student work. They reported on three cases in particular in their first two papers and the classroom overall in their 2009 papers. One case outlined a girl who moved from being a non participator in the class to being a key member of the class. This was seen as an example of how fluid student identities can be. Identity is not single. A person can experience many different identities depending on which communities or figured worlds they inhabit. These multiple identities are often hierarchically valued or positioned through peer relationships and societal structures. This girl exhibited personal agency in authoring her identity (i.e. she changed/re-wrote in her own words her identity to fit the new community/figured world she wanted to inhabit). To modify her identity she was both empowered and supported by her peers and her teacher. The other two case studies illustrated how two other girls authored new and non-traditional science learner identities that merged their life worlds with the world of school science (two different communities/figured worlds). Again these girls demonstrated a strong sense of agency through authoring of these novel identities.

The 2009a paper discussed how the classroom itself consisted of three emergent figured worlds – that of a storytelling world, that of being a 'real' world and one that allowed diverse, authentic, science-based participation. The storytelling world involved the students telling stories about how they experienced science in their home, whilst travelling and in their neighbourhood. The figured world of being real utilised the students' 'youth–based reality' which was comprised of the discourses and practices that dominated the students' out of school experiences. The third world, that of a diverse, authentic, science-based participation, was where the students took up roles other than that of a traditional student (for example, pet caretakers, plant caretakers and student leaders). This allowed all students, even the less prominent ones, to gain ownership, authority and agency in science. These figured worlds were not distinct but diverse and shifting. The students within the class engaged differently with each figured world and their science identities also developed differently in each figured world.

Calabrese Barton and Tan (2010) also looked at science learning in informal, inner city, after school science clubs. These clubs encouraged learners to embrace the figured world of science by developing their locally instanced sense of agency. The students here actively engaged with the out of school activities that allowed them to develop an identity not usually available to them within the school setting.

Out of school science clubs have also been a focus of research by Rahm (2007) and Rahm and Gonsalves (2012) to investigate how students' science identities develop within a figured world of science and scientists that does not have the constraint of being seen as 'typical school science'. Rahm describes how at the start of a summer science club most students described scientists using the typical stereotypes described in Chapter 2. They could not see themselves as part of this figured world of scientists as it was too different from how they saw themselves. After meeting and interviewing practising scientists, the students came to see them as 'being human' and reported that the figured world of scientists was not as far from their views of themselves as it had been originally. Rahm and Gonsalves reported that, when girls first encountered the after school science club, the figured world of normative science (i.e. one that is authoritative, incontestable and where girls don't do it) is reproduced. However, as the girls engaged with the programme, they came to construct temporary science identities and become partial insiders of the world.

Most young people learn about science within the figured world of school science. Within a school there will be the figured worlds of the different school subjects as well as the figured world of the school as a whole into which pupils bring their social worlds from outside school. The figured worlds of the school classrooms are systems of social activity that are governed by the norms (for example, the patterns of interaction, values, actions, behaviours expected) of that classroom. Within these figured worlds, the pupils see and position themselves as different kinds of people. Varelas et al. (2011) reported on three classrooms (one first grade, one second grade and one third grade) in an urban, economically struggling area of the US. Even at this young age, pupils saw themselves as 'doing science' and/or 'doing school' within a science classroom. How the pupils saw themselves within science and how they saw science overall was shaped by the ways they saw competence in the classroom and by the feedback given by the teacher. Competence in science was perceived by pupils as those who could build, design, observe, figure it out, get it right and discover and competence in the classroom was seen as working hard, helping others, respecting the teacher, learning lots of information, doing well in tests and working for higher grades. Those pupils who saw themselves as scientists within this world felt that it gave them status, made them feel good and allowed them access to further knowledge and education.

The links between school and science and the roles available to young people within a science classroom were investigated by Shanahan and Nieswandt (2010). They found that students had a clear view of what the typical science student's role was within a science classroom, within the figured world of normative science classrooms. Science students were expected to be intelligent, demonstrate scientific actions and attributes, exhibit scientific skills and display overall good behaviour. These attributes were consistently identified by both male and female students and by science teachers.

Price and McNeill (2013) have recently looked at how using a different science curriculum can foster links between the different figured worlds that school pupils inhabit. Working in the US with a high school ecology curriculum they found that the science curriculum could serve as a pivot between the world of the scientist, the world of the educator and the world of the student. Even though each of these participants brought different meanings to the curriculum, there were opportunities developed where the different figured worlds could intersect. Influences of the teachers on the figured world of science were investigated by Gilmartin et al. (2007). They found that amongst 1138 10^{th} grade students in five Southern Californian schools the percentage of female science teachers had no effect on emerging science identities. Students were much more likely to respond positively to teachers who were caring, challenging, engaging, passionate about their subject, fair and who made links to actual science regardless of their gender.

Investigating the different figured worlds of classrooms has also been used in mathematics education by Boaler and Greeno (2002). They carried out 48 interviews with high school students from six schools. They found that within these schools there were two distinctive figured worlds of mathematics classrooms – those that used traditional didactic teaching methods and those that used a discussion based teaching model. Within these two figured worlds students positioned themselves differently. Within the didactic classrooms the students' roles were narrowly defined; they were required to find the one correct answer, to think of mathematics as a closed, rule bound subject and to be passive receivers of knowledge. Within the discussion based classroom the students were engaged in negotiation and interpretation and were more active learners. Boaler and Greeno found that many able mathematics students did not want to author an identity that was part of the didactic classroom figured world; the students did not want to author an identity as passive receivers of knowledge. Within the wider figured world of the school, students moved between the different figured worlds of the individual subject classrooms and authored different identities. The choice as to whether to continue to study mathematics was a part of the identity formed within the mathematics classroom's figured world that the students encountered.

As mentioned above, it is not just the figured worlds of the individual subject classrooms that students encounter at school but the figured world of the school as a whole. The figured world of the whole school has discourses, practices, categories and interactions that can shape learner identities. Rubin (2007) investigated a US school where its students were classified as urban and deficient, used pedagogical practices that focused on rote learning and negated inquiry and saw humiliation as an acceptable form of interaction. For students who did not want to see themselves as this type of learner they found life at school to be very difficult. They did not fit into this figured world and could not develop meaningful identities as learners within it. Freire et al. (2009) working in Portugal with 'at risk' students found that many of these students wanted to succeed at school but that the figured world of school did not allow them to pursue their own path towards this goal. If they did not conform to the expected norms of the figured world and take up the positions available there, and given to them by teachers, they found themselves on the edge of the world and unable to engage fully with it, so leading to school exclusion.

As with Danielsson (2012) who used communities of practice to look at undergraduate physics students, Gonsalves and Seiler (2012) used figured worlds to look at the worlds of physics doctoral students. They found that the figured world of physicists resounded with the discourse of recognisable physics (i.e. stereotypical physics as described in Chapter 2). Women within this world had to decide whether to conform to the stereotypes offered to them or not. They found that for many women, being recognised as a physicist was the key component to their engagement with the figured world. To inhabit this world, the women had to perform, in varying degrees, stereotypical physicist attributes and recognisable physicist attributes.

As identity is being worked on within the figured worlds that students encounter, it can be thought that this identity work is being done along an identity trajectory. The concept of identity trajectories was first proposed by Wenger (1998) who said that identity was not a static phenomenon but was one that moved along a trajectory; identity is in constant motion. Calabrese Barton et al. (2013) used the concept of identity trajectories within figured worlds to describe the identity work carried out by two African American girls who they followed over three years during their middle school careers. They described the science classrooms where these girls learnt science as being comprised of a complex web of many figured worlds. For example they observed two worlds frequently; that of whole group activities and small group interactions. Both of these worlds have historical and cultural norms that describe participation and what it means to be a 'good student'. The pupils in the class were involved in the process of authoring and reauthoring themselves through participation in and resistance to the practices of these figured worlds (illustrated in figure 3.1).

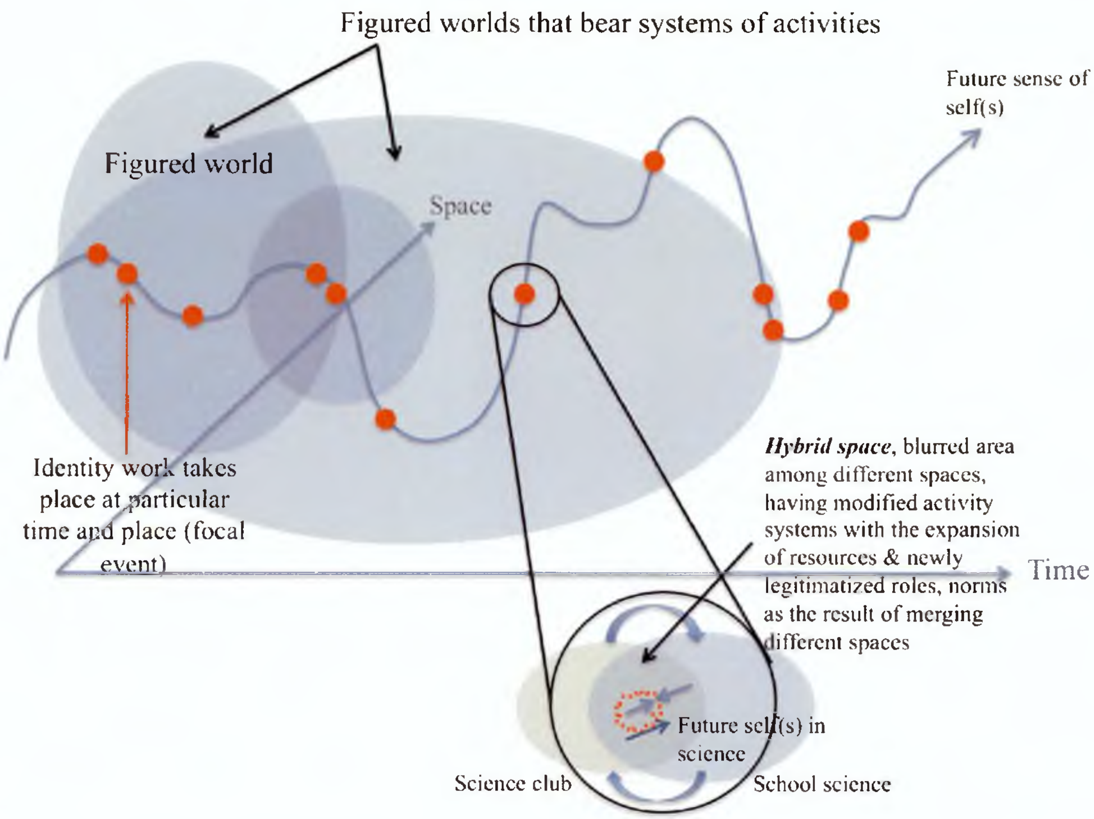


Figure 3-1 Configuring identity trajectories (p66)

The two cases describe two different identity trajectories. Firstly there was Diane who was described as having 'complex contradictions'. She saw science as a way of understanding the world and a tool for solving problems but never identified herself as being 'good at science'. Her identity work lost momentum as she had to choose between competing memberships of differed figured worlds that she had compartmentalised. In contrast to Diane was the trajectory of Chantelle whose identity work towards science gained momentum across the many figured worlds she encountered both within science classes and at a science after school club. At the science after school club she found she could use dance and acting to explain scientific concepts to others so found many figured worlds came together; she did not have to choose between them as Diane felt she did. These girls made very definite shifts in their science identity trajectories when they either came to see themselves in respect to science in a different way or perceived that others viewed them in a different way. These shifts were made as a result of either finding new meanings in their relationship with science or by coming up against closed and inflexible structures that did not align with their science practice.

The concept of identity trajectories, explained above, was also used by Jackson and Seiler (2013) to describe how late comers to science identified with the figured world. They classified these students as having one of three overall science identity trajectories (or combinations of the three) over the time that they were enrolled in a 'catch up' science programme at a Canadian college. These three trajectories were:

a/ inbound – an increasing identification with science
b/ outbound – a decreasing identification with science
c/ peripheral – identification near the dividing line between identification and dis-identification.

These overall trajectories were not constant but a 'line of best fit' through the fluctuating identities at any moment in time (see figure 3.2).

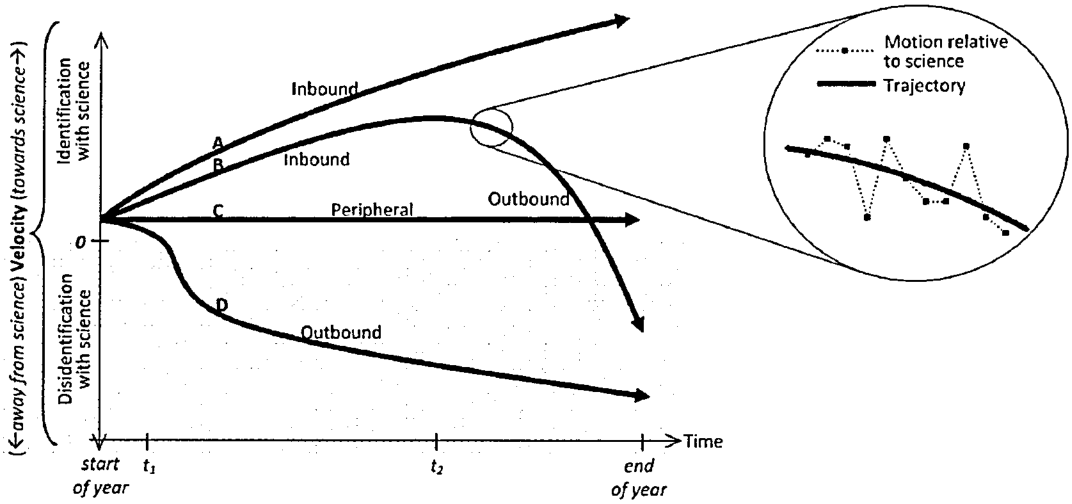


Figure 3-2 Representations of four of the many possible science identity trajectories a hypothetical latecomer to science may construct during her first year in CEGEP science. (Zero on the identification axis represents the dividing line between identification with, or motion towards science, and dis-identification with, or motion away from science. The magnified view illustrates a finer time scale and shows the curve of best fit drawn through the scatterplot of points representing motion relative to science. Although shown for only one trajectory, it highlights that all trajectories entail shifts and variation in identification over time.) (p830)

Jackson and Seiler found that the identities of the students they investigated were often shaped by the constraints of the cultural models within the figured world of the college science programme. The figured world of the science programme was embedded within the wider figured worlds of science and education and these wider figured worlds contributed to the resources available to the students and therefore impacted on their trajectories. However, the figured world of school science does have its own distinct historic and cultural norms that ultimately describe what it is to be, and to be seen as, a successful science student. It is this combination of factors from both the school science world and the wider worlds it sits within that often provoke or nurture critical shifts in trajectory, for example from an inbound to an outbound trajectory. In order to persist in the programme (have an inbound trajectory), students needed to improvise in order to maintain their identity trajectory and a thickening of their identity was related to the accumulation of resources to help them be successful on the programme.

The outcomes from the research using figured worlds as the theoretical framework in which identity development takes place are similar to those where communities of practice are used. However, as described above, the figured world theory allows for a more flexible way to study the way learning takes place in both classroom spaces and all the rest of the spaces that make up a young person's world. Many science classrooms, and to some extent outside school science learning spaces, present a figured world of 'normative science' and this can mean that students participate in it to differing levels over time. As different figured worlds emerge in these spaces, students can develop different identities. An issue here is whether these different figured worlds, and the identities that are developing there, are mutually exclusive or overlapping. As the student's identity develops, it follows a path; an identity trajectory.

Communities of Practice or Figured Worlds?

As outlined in the previous sections, both communities of practice and figured worlds have previously been used to provide a theoretical framework when researching the development of science and physics identities. These theoretical frameworks have been used both separately (e.g. Brickhouse, Lowery and Shultz, 2000) and together (e.g. Tan and Calabrese Barton, 2007) to describe science identities with no effort, when they are used together, to distinguish between them. Communities of practice have been described as figured worlds and vice versa. In this section, I start the discussion about some of the differences between communities of practice and figured worlds, and why I used figured worlds to analyse my data.

Over the years since Lave and Wenger first proposed their communities of practice theory (1991), the theory has been developed (Wenger, 1998) and it has been used to describe a variety of situations. My arguments are based on the original 1991 theory. Here, participation in a community of practice, and so developing an identity within that community of practice, is based on legitimate peripheral participation. Newcomers to a community of practice observe the practices of old times who in turn teach the new comers the practices of that community. Over time, the new comers, through practice, themselves become old timers. The physics classroom, however, is not a place where physicists are teaching and introducing new comers into the community of professional physics. Physics teachers are instructing their students on the principles of physics to meet the requirements of the National Curriculum and in the hope that some of the students will be inspired to study physics further. Learning in a physics classroom is based on a student acquiring knowledge individually not as part of a social practice within a contextualised community.

Participation in a figured world can be more varied and can take many forms, including disaffection. Participation in a figured world can be at many different levels and is dependent on how much the figured world becomes part of the overall identity of each participant. Participation in figured worlds is not based on new comers being shown the ways by old timers. In one of the examples used by Holland et al. (1998), that of the world of romance, participants are assumed to have knowledge of what the world is and they then choose how much they wish to be part of that world. This is similar to what has been described as 'usual school physics'. This figured world has both a historic and social context. Participants know what the world of 'usual school physics' looks like without having to be introduced to it by old timers. This figured world can be shaped and re-shaped by participants as they find their position in that world.

The freedom to find a place within the figured world of the physics classroom, as impacted on by other figured worlds, is due to the dialogic nature of identity. This allows individuals to develop an identity that is composed of a number of different views simultaneously regardless of any tensions or logical compatibility between them. The historical nature of the figured world allows participants to develop a history of person (Holland and Lave, 2009). Further, one's identities, once they have become formed in history in person, provide a ground for agency whereby each individual can improvise their behaviours to form an identity that clearly reflects their position within that world. Communities of practice do not allow such freedom as agency to shape the community only comes about once full participation is achieved.

The physics classroom can be thought of as a figured world in its own right but other figured worlds impact on it and can influence how much a girl engages with it. These other figured worlds can include that of a conscientious student, that of a school ethos of hard work and striving for achievement, that of a social place amongst peers, that of family, that of how society in general perceives girls who engage with physics; or more generally, the life world of that individual. An individual has the power to find their own place in each of these worlds but within the constraints of that place being recognisable to others, a component part of identity development.

Self Efficacy

In the introduction to this chapter, I described that originally my intention was to investigate the two topics of identity and self efficacy as separate entities, as had been done previously. Studying the literature of both identity and self efficacy showed how closely these two were related to each other. For example, in their discussion of how the Eccels et al. (1983) model of choice can be used in the Scandinavian tradition of linking choice to identity (see Chapter 2), Boe et al. (2011) discuss how identity forms expectation and values and thus affects achievement related choices. They then go on to describe how components of the model relate to both identity and self efficacy. This section on self efficacy starts with a definition of self efficacy before linking it to identity and briefly reviewing some of the self efficacy literature that can add to our understanding of identity.

Self efficacy is a psychological quality which Bandura (1982) defined as 'one's perceived capabilities for learning or performing actions at designated levels' (p122). He argues that self efficacy is not a fixed act or simply a matter of knowing what to do. Self efficacy is concerned with a person's judgment of how well they can execute courses of action to deal with situations. In order to do this, cognitive, social and behaviour skills must be organised into a course of action.

This definition suggests self efficacy forms a part of one's identity. If identity can be thought of as how we work towards the process of coming to think we know who we are within a figured world then our perceived capability of learning or performing within that figured world, our self efficacy, must form part of our identity. This is further confirmed by Bandura's classification of four causal factors that affect a person's level of self efficacy as they can also be seen as factors that influence our identity.

Bandura's four causal factors for affecting the level of self efficacy are:

1. mastery experience
2. vicarious experience
3. social persuasion
4. physiological states.

Mastery experience deals with previous performances of tasks. Experiences that have previously been successful generally raise a person's self efficacy whereas failures lower it. Self efficacy can be most affected by successes that have resulted from overcoming challenges. Vicarious experiences arise from seeing similar others perform a task. This is based on 'if they can do it, I can too'. The more similar in nature the 'other' is to the observer, the greater the influence on their self efficacy. Social persuasion is the exposure to both verbal and nonverbal judgements or feedback on previous experiences. When giving feedback, it is much easier to weaken self efficacy through negative comments than it is to raise it through positive feedback. The final factor that can affect self efficacy is physiological states, for example, anxiety, stress, mood states. How these affect self efficacy is based on how much belief a person places in these as indicators of success or failure.

Reading the literature about self efficacy in science, physics and mathematics also brings to the fore another issue: the interchangeable use of different terms to define the same or very similar qualities. Within this research the terms self efficacy, self concept, self perception and self belief are all used, often interchangeably[10]. This brief review focuses on self efficacy research that, if we think of this as part of our identity, can add to our understanding of how identity develops and is influenced within the figured worlds that we encounter.

Studies of self efficacy

A review of self efficacy development in adolescents was carried out by Schunk and Meece (2005). They looked in detail at how adolescents' self efficacy developed using the four sources identified by Bandura. They found that school influences, families and the home environment and peers had significant effects on self efficacy. The school influences included how teaching was structured, the ease or difficulty of learning, how teachers gave feedback on performance and graded work and how much and the type of attention given to pupils by the teacher. They found that classrooms where the emphasis was on competition and performance goals led to a decline in self efficacy. Self efficacy increased in classrooms where the emphasis was on the importance of effort, meaningful learning, self improvement and collaboration and where student interests were taken into consideration in the learning contexts used. Self efficacy was higher in adolescents where the family provided an environment that encouraged them, set high but realistic aspirations, contained positive role models and provided support for mastery experiences. Adolescents were found to be greatly influenced by their peers. Their self efficacy could be raised by observing peers accomplishing tasks, especially those from their own, self selected, peer group – that is those peers with similar levels of attainment and interests.

Self efficacy has been found to be a strong predictor of academic achievement, course selection and career decisions (Britner and Pajares, 2006). Britner and Pajares carried out a quantitative investigation into science self efficacy and self concept beliefs in 319 (155 boys and 164 girls) US middle school students. The survey included questions asking the students to give opinions, using a Likert scale, on science self efficacy (for example: I got a good grade in science last

[10] In the discussion of the literature, when discussing particular texts, I use the term used by the authors. In my own discussions, I use self efficacy.

semester, My teachers believe I can do well in difficult science courses); on their science self concept (for example: Science is easy for me); on their science anxiety (for example: Science makes me feel uneasy and confused); on their general self efficacy for learning (for example: How well can you finish your homework on time?); and to report their science achievement. Britner and Pajares found that mastery experience had the greatest influence on self efficacy. They also found that the differences between genders was minimal, although girls reported a slightly higher anxiety about performance in class and more confidence in their ability to manage studies whereas boys reported a slighter higher self concept in science . It is interesting that they found little difference between the genders, as previous studies (Heller and Ziegle, 1996; Meece and Jones, 1996) had found that females tended to have a lower self efficacy in science than males.

Specific examples of research into self efficacy/concept in physics are limited. Haussler and Hoffmann (2002), in Germany, carried out a classroom intervention study to see if they could enhance girls' self concept of physics. The intervention took a whole school year of some 60 one hour lessons and comprised 12 experimental and 7 control classes of 13 year old pupils. Their physics related self concept, as well as achievement and overall interest in physics, were assessed by written tests at various stages of the intervention. Overall, they found that several changes (for example, adapting a curriculum to account for the interest of girls and using gender fair teaching) could be made in the classroom to enhance girls' interest, self concept and achievement in physics.

Self efficacy and learning content in a Chinese physics classroom was also the subject of a paper by Zhu (2007). She reflected that when she herself was learning physics in China she did not learn well in junior high school. This she felt was not due to a lack of ability but that the physics she was learning did not make sense to her and also to many of her female classmates. This, she felt, was due to the lack of variety in the physics teaching and a boring text book. She had a better experience at senior high school, where, although the physics content became more abstract, the teacher used more meaningful activities to explain concepts and also used more collaborative activities. When she became a physics teacher herself she tried to use ICT to give examples of physics phenomena and to make physics learning fun and relaxing. She concludes by saying that there is a relationship between the learning content of physics curricula and physics self efficacy and, to some extent, girls' development of gender identity.

A quantitative study of the relationship between self efficacy and retention in an introductory physics course at a US college was carried out by Sawtelle, Brewe and Kramer (2012). They surveyed 352 students both pre and post course. They found that for women, their self efficacy was greatly affected by vicarious sources; that of seeing similar others being successful in a given task or assignment.

To summarise, it has been found that the school, particularly teachers and teaching, the family and peers can all influence the level of a person's self efficacy. Poor support from all of these groups led to a decrease in self efficacy. The literature discussed in Chapter 2 looking at subject choices and the reasons for those choices also showed that students were less likely to choose a subject if they did not have the support of their family and friends and if they encountered poor teachers and teaching in those subjects. Self efficacy has also been found to be a good predicator of future course and career selection. The lower the reported self efficacy for a subject, the less likely a person is to choose that subject for future study.

Identity, Self Efficacy and Narrative

In this section I focus on literature using narrative to investigate identity. Narrative is an essential part of investigation of figured worlds; the stories we tell about how our identities developed within a figured 'as if' world. Some of the papers already discussed in the section about science education and figured world used narrative as one of their research methods (Johnson et al., 2011; Gonsalves and Seiler, 2012;Kane, 2012a and 2012b; and Guerra et al., 2012).

The work discussed below does not use figured worlds as a theoretical framework but does use narrative.

Sfard and Prusak (2005) used narratives to investigate identity. In order to do this they offered a new definition of identity as collections of stories about persons, or those narratives about individuals that are reifying (real to them), endorsable (supported) and significant (caused a change). With this narrative definition of identity the dynamic nature of identity is brought to the fore. Narratives will always have authors and recipients (although they can be the same person), are collectively shaped and can change according to the authors' and recipients' perceptions and needs. Identities can be therefore be seen as either actual or designated. Actual identities are those stories about the actual state of affairs and designated identities are stories about what is expected to be the case. They propose that learning can therefore be thought of as closing the gap between actual and designated identities.

This definition of identity, that we have both actual and designated identities, was also used by Tucker-Raymond et al. (2012) in their work with 54 first, second and third grade children. They asked these children to draw images of themselves and science and then talk about them both before, during and after they had studied a year's science course. They found that the pictures and the stories attached to them changed as the pupils' identification with science developed during the year.

A combination of Gee's description of identity as the kind of person we are and Sfard and Prusak's actual and designated identities was used by Pike and Dunne (2011) to discuss their findings on students' post-16 choices. Their three identified factors (school pedagogies, discourse of difficulty and future careers) all had a major influence on the students' learner identities, their identification with science and their choice as to whether to study science post-16 or not (see Chapter 2).

The ASPIRES project in the UK has looked at how primary school children engage with school science and explored their attitudes toward science and interest in science. Some of their findings have been discussed in chapter two (Archer et al., 2013 and De Witt et al., 2013). In a 2010 paper Archer et al. looked at 'doing science' and 'being a scientist' using focus groups to gather data and analysed the data using narratives and how the pupils formed an identification with science. They found that many children enjoyed science but did not see themselves as doing science because the image of a scientist clashed with their images of themselves. Scientists were seen to fit the stereotypical images discussed in chapter two.

Looking at discourse rather than narrative, Hughes (2001) looked at how secondary pupils talk of both the importance of gender and ethnicity in the production of, or rejection of, 'scientist identities'. She found that hegemonic masculinity provided a comfortable 'scientist identity' for some males, but that for girls femininity and 'physical scientist identities' were incompatible unless 'othered' by ethnicity.

Working with the children of migrant workers in the US, Kozoll and Osborne (2003) told the stories of four students; looking at their life worlds and the world of science. These students all had a different relationship with science. There was Hector who felt that his world and the world of science were so different that they would never connect; Clara whose identification with science changed when she was allowed to use her creative side in science class; Andrea who saw science as a place where she could be an insider; and finally Keith whose understanding of science allowed him to understand himself.

Walshaw (2005) also uses narrative to investigate one girl's interaction with mathematics within a school setting. The girl's identification with mathematics is complicated and influenced by past beliefs about girls and mathematics where these beliefs are 'not discarded but are simply shifted to, and contained within, her present' (p31). This narrative is also constructed in relation to significant others in the girl's life – her family, her teacher, her best friend and her mathematics classroom peers. Overall the girl's identification with mathematics is 'produced through a convergence of a number of often competing discourses and practice, each vying for her attention, and all of which position and designate her in some way' (p24). This has a direct parallel with identification with physics, or any subject.

Narratives were also used by Mendick (2003) in her work on masculinities in mathematics. She looked particularly at how mathematics became part of a gender identity and how young people worked at being male or female through their identification with mathematics. Jenkins description of identity as who we think we are and who others think we are is of particular relevance here as these young people came to work on who they were in relationship to mathematics and their overall gender identity and how the two worked together. Mendick also describes how she sees that identity in general, and gender in particular, is a project that is achieved by interaction with others – how they see us. For mathematics, choosing to study it or not becomes part of our work towards identity and gender. The main discourses at play in this process for mathematics are that mathematics is 'hard'; that it is proof of intelligence and a signifier of social incompetence. These discourses are gendered so that it makes it more problematic for girls to identify with the subject and so make the decision to choose to study it.

Using narratives to investigate identity development allows us to study the stories people tell about how their identities develop from what Sfard and Prusak (2005) term their actual (or now) identities to their designated (or how they see themselves in the future) identities. These stories change as identity work takes place. Influences discussed in these narratives as impacting on identity development include the discourse of science as hard; wanting to pursue a fulfilling career; social perceptions of the image of science, physics and scientists; and how the world of science interacts with the wider world. These influencers of identity development are the same as those discussed in Chapter 2 when discussing the influencers of subject choice.

These narrative accounts of how young people do identity work seemed to me both telling and powerful. I therefore was drawn to using a similar approach in my analysis (see Chapter 4).

Summary

As can be seen from the above discussion of the literature, a variety of ways of using the concept of identity has been applied in research on girls and science, physics and mathematics. I started the chapter by developing my own working description of identity based on the work of Jenkins (2009) and Gee (2001). This is that we each have an individual identity where we work towards the process of coming to think we know who we are, thinking we know who others are, them thinking they know who we are, us thinking we know who they think we are and so on. I also proposed that we work towards our identity in the many figured worlds (Holland et al., 1998) that make up our society. It is in these figured worlds that we come to recognise ourselves and others as certain types of people. Our identification with science and physics in particular is formed within those figured worlds where we encounter physics; both those in a school classroom and those outside. These figured worlds are part of the wider figured world of our lives and the wider figured world of our lives is composed of many smaller figured worlds. How we negotiate our identities within all these figured worlds allows us to become to know who we are. Our relationship with physics, our identification with physics including our associated physics self efficacy, is dependent on how much the figured world of physics plays a part of our wider figured world from a major part to only a minor part.

The research discussed in this chapter uses a variety of ways of understanding identity and there are many points that will re-emerge and inform my analysis. Using narrative to investigate identity, which Sfard and Prusak (2005) describe as the process of 'collecting stories we tell about ourselves' (p29), led them to describing identities as actual (where we are now) and designated (where we want to be). Collecting people's stories also highlighted the links between gender and ethnicity and science identity (Hughes, 2001). Girls often described that femininity and physical science identities were incompatible unless they were 'othered' by ethnicity. Similar descriptions were found by Walshaw (2005) and Mendick (2003) for mathematics where choosing to study mathematics became part of identify work and of gender work. That identity work includes issues of gender was also described by women already working in physics who found that they often had to decide whether to conform to the expected stereotypical view of being a physicist and how this impacted on their femininity and gender identity (Danielsson, 2012 and Gonsalves and Seiler, 2012).

Looking at self efficacy showed the links between this and identity. Self efficacy has been proposed as a predictor of academic achievement and future subject choice with the higher the self efficacy the higher the achievement and the more likely someone is to choose to study that subject further (Britner and Parjares, 2006). Girls are generally found to have a lower self efficacy than boys (Meece and Jones, 1996) especially in science subjects. Since choice is part of identity work, and self efficacy can predict choices, links between the two need to be made.

How identity develops over time can be described as an identity trajectory (Wenger, 1999). Our identification shifts at key points in time (Barton et al., 2013) and can lead to three possible overall trajectories to describe our relationship with science (Jackson and Seiler, 2013). Whether we choose to persist in a study of science or not led Aschbachter, Li and Roth(2010) to categorise this persistence and relate this to our identity work.

As Aydeniz and Hodge (2011) say 'identity is a complex structure for researching a student's academic behaviour' (p500). As I explain in the chapter which follows, this led me towards using interviews to find out how girls' identification (and self efficacy) with physics developed. Taking this a step further, narratives from individual girls were developed to give examples of identity work being undertaken with respect to physics.

Chapter 4 Methodology and Method

Introduction

This chapter outlines both the methodological thinking that went into the project and the methods used to gather the data that is analysed in later chapters.

The research moved through three iterations of methodological thinking and these are described in detail in the chapter. The methods used, or proposed, for data gathering in each iteration are also described.

Methodological Approach

Methodological thinking and the methods used to carry out research are interlinked and there is often a cyclic process between the two. At the start of a research project much methodological thought is put into justifying why a certain method or methods are chosen to investigate a topic. Whilst the research is progressing the methods will be modified as problems and data emerge.

Methodology has been described as a combination of epistemology, ontology and method (Pawson, 1999). Traditionally, epistemology has been concerned with what distinguishes different types of knowledge claims (Usher, 1996). Researchers will approach a project holding certain assumptions about what they will find and how they will find it out (Creswell, 2003). Purists will say that researchers have to work within just one paradigm, that paradigms are incommensurable and there is no possible way that research carried out in different paradigms can be compared (Coe, 2012). Some researchers hold to the stance that paradigm differences do not require paradigm conflict and that, depending on the question to be answered, different approaches are appropriate. This is a stance I support and one that informed this research.

It is suggested (Guba, 1990) that there are twenty one different ways to define paradigm. The most common, or generic, definition is that it is the basic set of beliefs that guides action. Paradigms can guide disciplined enquiry. My background is in physical sciences and the majority of physical scientists work within a positivist epistemology. The underlining principle of positivism is the use of scientific method (the systematic observation, measurement and experimentation needed to test and modify a hypothesis) to discover truths about the world (Willis, 2007). Positivists believe that the events in the world follow a lawful and orderly pattern that can be discovered by close observation; that different observers will reach the same conclusions when looking at the same data; and that when questions are put to nature, nature answers back directly. My previous research into the mode of action of enzymes as a research chemist would fall easily into a positivistic paradigm. In this research project, I wanted to try and understand aspects of the individual. In my view positivistic research is not a route to understanding all aspects of the individual and their identity. Trying to understand the individual led me to post positivism.

The post positivist researcher is a 'naïve' realist. They believe that the real world is driven by real natural causes and it is possible for humans to perceive it. They still believe that there is an ultimate truth out there even if they cannot uncover it. These researchers therefore still carry out detailed observations and measurement of variables in order to test theories that are continually being refined. Findings to support, or which lead to a modification of, the theory, emerge from the interactions between the inquirer and the inquired. Each participant in the research will give a range of perspectives about the topic being studied. This leads to the findings being based on many sources of data which in turn means that the findings are less likely to be distorted by interpretation; they will be objective and unbiased. Post positivism led me away from positivism in a useful direction but still did not give me a route to understanding how a group of girls described their relationship with physics. This journey took me towards constructivism.

Creswell (2007) describes social constructivism thus:

> Individuals develop subjective meaning of their experience. These meanings are varied and multiple. Often these subjective meanings are negotiated socially and historically. In other words, they are not simply imprinted on individuals but are formed through interaction with others.
>
> p20

Understanding a phenomenon is formed through the participants and their subjective views. When these participants provide their meanings, they speak from meanings that are shaped by both social interactions with others and from their own personal histories (Creswell and Plano Clark, 2011). Therefore, when collecting data it is important to collect and respect each participant's view of the situations and use those views to develop a pattern of meaning. In order to collect this type of research data the questions to be asked need to be broad and general so that participants have the space and time to construct their meaning of a situation. The findings will, however, be the creation of the interaction between the inquirer and the participants; the inquirer (me) will be interpreting the views expressed by the participants in order to find broad patterns and come to broad understandings of the phenomenon. In this interpretation, I must recognise that my own background and my own prior assumptions will shape my interpretation of the participant's views. The findings will not be objective but subjective.

Combining post positivism with constructivism informed my methodological approach. The research presented here has a positivistic aspect, a quantitative questionnaire[11], which was used to inform qualitative, constructivist, investigations using group interviews and individual narratives to try to answer the question of how identities and self efficacy influence future subject choice. A pragmatic perspective suggests that both of these approaches can be explored together, using mixed methods, since each is giving answers to a different part of the overall question (Flick, 2011). Pragmatism focuses on the consequences of the research and highlights that it is the research that is of primary importance

[11] Quantitative questionnaires are mostly associated with positivism, and in this research this was the case, but not exclusively so.

rather than the methods used to investigate it. Multiple paradigms can be used in mixed method research; the researcher just needs to be explicit in their use and reflect each world view in their reports. My work in this thesis reflects such a mixed methods, pragmatic approach.

The initial proposal for the research was a case study of two cases. This would use a combination of methods (questionnaire, small group interviews, lesson observations and supporting evidence) to investigate the cases. As I progressed with the data gathering, it became clear that I would not be able to complete all of these originally intended aspects of the case study for each case due to issues with one of the schools around lesson observations. I therefore decided to focus on the group interviews as the main data gathering tool. As I started to analyse the data from the group interviews, I became interested in some of the individual stories that were emerging. The final iteration of my methodology I am terming a funnelling approach to a mixed methods methodology. I started with a questionnaire given to a large number of pupils, including 202 girls. From this questionnaire I selected 43 girls to participate in group interviews. I then selected a further five (that became four) girls for whom I would tell their stories in more detail and three of these I interviewed individually to add more data to what they had given me in the group interviews. These final life stories are described using narrative analysis. The rest of this chapter describes the methodological understanding that informed this research design and gives more detail of each of these iterations.

Pilot Research

Prior to starting the work on this doctoral research I completed a Masters research project (Thorley, 2010). My teaching background is in Further Education and using my contacts in this sector I interviewed five girls[12] who were just completing their first year of A-level study including physics. These

[12] These were all girls who agreed to participate in my study after being asked if they wished to do so by their lecturers.

five girls had combined a study of physics with a variety of other subjects. I found that I could split these girls into two groups – those who had included physics as part of a science A-level programme and those who had included physics as part of a mixed programme. All the girls said they were studying physics because they were interested in the subject, but those who were following a science programme had also included it because it would help them to reach their future career goals.

I carried out a single, semi-structured, one to one interview with each girl for this research, which I audio recorded and then transcribed. These girls were all 16 or 17 and used to studying in an environment where they were on a more equal footing with the adults that they encountered than they probably would have been in a school. Therefore, I felt that they were comfortable in talking to me in the one to one situation and that they gave me detailed answers to the questions that I asked.

I found that those girls who were studying physics in a mixed programme were confident in themselves. They were prepared to study a subject because they enjoyed it, not because they saw it as leading in any particular direction or to any particular career. They were not influenced by what other people thought of them and not worried that they were studying a subject that other people might see as being masculine.

In extending my research for the PhD study I was interested to see if this pattern of physics study, either as part of a science A-level programme or as part of a mixed programme, was evident in younger girls who were thinking of choosing physics for further study.

Case Study Methodology

As stated above, when I initially started on this research process I intended to use a two case, case study approach. A case study approach seemed to be the best methodological fit for my initial research aims. Yin (2009) defines a case study as an investigation of the how and the why of a contemporary set of events within its real life context using multiple sources of evidence. The case is the situation, individual, group or organisation that we are interested in (Robson, 2002).

There are many different types of case study. Robson (2002) gives six examples of the usual types of case study that are undertaken in social science research.

1. Individual case study – a detailed account of one person
2. Set of individual case studies – a small number of individual case studies where some common features are studied
3. Community study – study of one or more local communities
4. Social group study – describes and analyses relationships and activities of groups
5. Studies of organisations and institutions – for example the study of a school's best practice in areas of the curriculum
6. Studies of events, role and relationships – focusing on a specific event.

(p181)

My initial intention was to carry out two studies of the identified schools (type 5 from the list above) looking at how they encouraged more girls to study A-level physics. Once the researcher has decided on the type of case study, they need to be explicit about the purpose of the case study. There are many reasons for carrying out a case study and these could be classified as:-

1. Intrinsic – studying the subject of the case out of pure interest
2. Instrumental – to provide insight into a particular issue where the actual case is of secondary importance
3. Evaluative – to check how something (for example an intervention) is working
4. Explanatory – an in-depth investigation of a specific issue
5. Exploratory – finding out more about a perplexing issue.

Thomas, 2011, p53

I therefore class my case study as a combination of an exploratory study (I was interested in finding out more about the complex issue of girls' progression onto A-level physics) and an explanatory one (I was interested in carrying out an in-depth investigation into the issue).

My original intention was to select schools for the two case studies as a critical case sample (that is, ones where deductions can be made that if something worked at that school then it would work in all schools) (Flyvberg, 2007). Case studies, although they contain a subject and an analytical frame, are not good for generalising. They are good at giving a rich picture of the case within the boundaries of that case. Selecting schools as critical cases, however, would allow a certain amount of generalisation to take place. When I actually visited the schools, I realised that they were atypical (see below) so making generalisations would be impossible.

Case studies are not a method in themselves, but are made up of a variety of methods that all investigate a given event. These methods can include interviews, questionnaires, lesson observations, background written data and discussions with teachers and school officials. For my case studies I chose to use a questionnaire, small group interviews, lesson observations and supporting written data. All research could be called case study research; the distinction is the amount of information that is gathered using a variety of methods and different sources of data and how that data is used to look at relationships and processes (Gomm, Hammersley and Foster, 2000).

It was after I had completed the first round of group interviews and had further discussions with my contacts at both the schools that it became apparent that carrying out lesson observations would be an issue for one of the schools. I had included lesson observations as part of my case study methodology as case studies include a variety of data gathering tools used in conjunction to give an overall picture of what is happening in that case. Each method is used to triangulate data from another method, so giving validity and reliability to each individual data gathering method. I also realised that the data from my group interviews was giving me very rich descriptions and that focusing on the group interview data would be more valuable than trying to continue down the original case study route and risk alienating one of the schools by insisting on carrying out lesson observations. The second iteration of my project then became a case study that focused primarily on the group interview data with supporting data from the questionnaire.

The third iteration of the project became one where the focus moved again to individual narratives. As discussed above, this iteration could still be called case study research as it is focusing on a set of individuals. I am not calling them case studies because I agree with Gomm, Hammersley and Foster that a case study needs to include information collected by a variety of methods and from many sources. The three sources used here do not, in my opinion, give a broad enough picture of the individuals to allow the narratives to still be classified as case studies.

School Selection

Previous research in the area of girls' progression onto post 16 physics has shown that a high percentage of A-level physics entries are from a minority of schools and that these schools are predominately single sex and selective (see Murphy and Whitelegg, 2006a). Single sex, selective schools make up only a small proportion of the total of secondary (post 11) schools in England. The majority of secondary schools in England are non selective, mixed sex schools that are funded by the government.

I decided to use two mixed sex, non selective, government funded schools for my cases. These types of school are where the majority of young people gain their secondary education. I chose 11-18 schools as these would have sixth form provision (i.e. they would offer A-level physics). The majority of pupils in the sixth form of an 11-18 school will have progressed into that sixth form internally (i.e. they will have attended the same school pre 16 and have taken their GCSE examinations at that school). I selected schools where a high number of their

GCSE pupils progressed onto A-levels since these were schools where, I conjectured, there was already a whole school ethos encouraging the study of subjects to A-level (Hampden-Thompson, Lubben and Bennett, 2011). However, I not only wanted to choose schools that had a good overall progression onto A-level physics but ones where there was a history of above average (19%) representation of girls in their A-level physics classes.

The National Strategies[13] data manager agreed to give me access to some of their data on schools that they had identified as having a higher than average progression rate onto A-level physics in 2009. I was not allowed access to the data on all schools throughout the country so chose nine different geographic areas. These areas were based on my home and that of friends and family and included all the schools within a 20 mile radius of the homes that were included in the National Strategies data. These two filters resulted in a list of 152 possible schools.

Further analysis of the data for these 152 schools showed that 94 of these schools had less than 10 pupils entered for A-level physics. I did not have the data for the overall size of these school sixth forms, but due to the small numbers in the A-level physics cohort I felt that these schools and their A-level physics cohorts could be too small to offer me a large enough cohort of pupils in years 9 and 10 for me to select girls to participate in the group interviews. I therefore rejected these 94 schools.

I then looked more closely at the remaining 58 schools. The National Strategies data filter for good progression only focused on overall A-level physics progression, not just for girls. Since I was interested in schools with a higher than average (19%) A-level physics representation for girls, I then eliminated those schools which did not meet this criterion. I was left with 16 schools. I contacted all 16 schools by letter and one school, Browning School[14], replied that they would be willing to work with me on this research.

[13] The National Strategies were a government funded body who looked at specific subjects to increase achievement in them.
[14] Browning School is a pseudonym.

The second school, Hinton School[15], that I worked with is outside the 20 mile filter applied to the National Strategies data so did not appear on that data. However, this school is within a one hour drive from my home so is accessible. One of the physics teachers from this school, a lead practitioner[16] for science at the time, attended a course at the Science Learning Centre Yorkshire and the Humber[17] looking at girls' participation in physics. I approached this teacher at one of the course sessions since her school met my selection criteria and she expressed an interest in my research. This meant that I now had two schools that were willing to take part in the research.

It was when I visited both the schools that I found that they were atypical. Although they were both mixed sex, non selective, government funded schools they both had a higher than average school population of White students and a lower than average number of students who were eligible for free school meals (an indication of socioeconomic background) (for full data see Chapter 5). This means that the schools are comparable to each other but not with all other schools in England.

Questionnaire

The initial research tool was a questionnaire (see appendices 1 and 2). It was designed to be used to find out some basic information about all those year 9 and 10 girls who had the predicted attainment to allow them to progress to study physics at A-level.

The initial intention of the questionnaire was to select girls to participate in the group interviews (see below) by asking just a few questions about future subject choices and the reasons for those choices. On reflection additional questions were added to it so that data could also be gathered about impressions of teaching

[15] Hinton School is a pseudonym.
[16] This teacher had responsibility to work with her colleagues to improve the quality of learning and teaching in science.
[17] This centre is based within the university of study.

and teachers, how pupils felt about physics and about physics self efficacy. The answers to these questions were used to support the selection of interview participants (see Chapter 6).

The questionnaire was issued to all Year 9 and Year 10 pupils (both girls and boys), at both schools, who were predicted to be able to gain at least a grade C for GCSE Science or GCSE Physics. It is these pupils who are assumed to have the academic attainment needed to study AS and A-level physics. This was done because the teacher contacts at both schools asked that the questionnaire be given to all members of a class as this would be easier for the teachers to administer. This now meant that I had questionnaire data for both girls and boys and so I was able to carry out a small scale comparative descriptive statistical analysis (see Chapter 5).

The final questionnaire had five groupings of questions – questions about future subject choices, about attitudes to science/physics lessons (see below), on opinions on science/physics teachers, about how they felt about physics and their physics self efficacy and finally some standard questions about socio-economic background and ethnicity as well as asking if the respondent would be interested in participating in the interviews. There were a mixture of open and closed questions and questions where the answer was a 3 point Likert scale. A Likert scale is a recognised format where respondents indicate their level of agreement or disagreement with a statement by choosing from a set of categories (Aldridge and Levine, 2001). Often, a five point scale is used by having both strongly agree and agree as well as strongly disagree and disagree. However, in many reports of questionnaires, the strongly agree and agree (and strongly disagree and disagree) categories are reported together (personal observations). In my design, I only offered three choices of answers since the overall purpose of the questionnaire was to select group interviewees and to offer a broad picture of views on science/physics teaching and teachers and physics in general. In section two the question from the UPMAP questionnaire was changed from a five point Likert scale to a 3 point Likert scale for the answers. Another reason for changing the UPMAP questions from a five point to a three point Likert scale was so that they had the same number of choices as the questions from Bennett and Hogarth's

(2009) study used in section three; i.e. all questions in the questionnaire had the same number of responses.

Asking about the full range of future subject choices, not just whether the respondents were going to choose physics or not, was included so that I could choose the groups for the interviews (see below). I was also interested to find out what range of subjects pupils were thinking of choosing to see if the traditional mix (either all sciences or all humanities) was still being chosen or whether more pupils were thinking of taking a wider mix of subjects post 16.

The second section asked about science and/or physics at school. The year 9 questionnaire asked about science whereas the year 10 questionnaire asked about physics. This differentiation between the years was introduced because both schools told me that they did not separate out the three sciences in year 9 and that many pupils might not be able to distinguish between the subjects. In year 10, both schools taught the sciences in separate classes so asking specifically about physics was not an issue. This section of questions was directly based on questions from the UPMAP (2008) Physics Year 8 questionnaire. Blalock et al. (2008) in their review of instruments used for measuring attitudes towards science found that many researchers preferred to reinvent the wheel rather than use existing instruments and that this resulted in many instruments not demonstrating good validity or reliability since they had not been rigorously pre tested (Babbie, 1990). Since the UPMAP researchers had reported that they had tested their questionnaire, I believed that using one of their questions would add to the validity and reliability of my instrument. It also meant that in my analysis of the data I could directly compare my results to those gathered in the UPMAP research. I asked questions about science and physics lessons so that I could relate my findings to the literature about attitudes to science. This literature found that, in general, pupils did not enjoy school science as much as other subjects.

Section three asked about science and/or physics teachers. This question was taken directly from the study of Bennett and Hogarth (2009) discussed in Chapter 2, with no alterations. Again, using a question from a previously tested instrument increased the validity and reliability of my instrument. This question focused on the students' attitudes to teachers and teaching and the interest the teachers fostered in science or physics. It has been reported in the literature that teachers play a major part in influencing future subject choice. Bennett and Hogarth report that the agreement with this statement decreases as students get older. I wanted to see if pupils at the schools in this research followed this pattern.

The fourth section asked respondents to choose words that described how they felt about physics and to write a sentence describing a 'physics type of person'. Two self efficacy questions, based on questions from a standard self efficacy questionnaire (Schwarzer and Jerusalem, 1979) were also asked. This group of questions was asked to see if physics self efficacy could be linked to future physics choice and to see if the girls held stereotypical views of what a physics type of person is.

The final section of the questionnaire asked for data on gender, ethnicity and socioeconomic standing of both parents/guardians if known. At the end of the questionnaire, respondents were asked to tick as to whether they would be interested and willing to take part in the group interviews.

Data from the questionnaire was analysed using SPSS. A code book (see appendix 3) was developed to allow input of the data from all the questionnaires (both girls and boys). The open ended questions were thematically coded. Descriptive statistical analysis was performed on the data (see Chapter 5). Using descriptive statistics allowed me to investigate relationships between boys and girls at both schools and for both year groups and to investigate similarities and differences between those boys and girls who were thinking of and not thinking of choosing to study physics (discussed further in Chapter 5).

Lesson Observations

Observation is a method that allows researchers to observe and record people's behaviour, action and interactions within a given setting (Hennink, Hutter and Bailey, 2011). During an observation the observer will watch what people do, listen to what they say and how they say it and observe how people interact with one another. In an observation the researcher may observe from the position of 'complete participation' or from 'complete invisibility' or from somewhere between the two depending on the observations they want to make and their involvement with the people being observed.

As part of the original case study proposal, I wanted to observe girls in their physics or other science subject lessons. My interest was in how the girls interacted with each other (for example, if they worked in small groups, did they work in groups they chose themselves or in groups allocated by the teachers; did they work in single sex or mixed groups and what roles did they take on in those groups); how they participated in the class (for example, were they willing to ask and answer question); and how the teacher interacted with girls (for example, did the teacher focus on boys or girls and did the teacher ask the same sort of questions to both boys and girls). For these observations I would not focus on girls who were part of my interview groups but all girls in the classroom. Observations would not be completely invisible as the girls (and boys) would be aware that I was in the classroom, but they would not be aware of what I was observing or who I was observing and I would not interact with them unless asked to do so. The teachers would be aware that I was interested in girls and physics but not the specifics of what I was observing in their classroom. I had made the teachers aware that I was not observing to assess their teaching and that the focus was on the girls not them (see appendix 12).

I was able to carry out observations in only one of my two schools. On both occasions that I observed lessons (see timeline in appendix 14) I was given a list of lessons that I was welcome to observe and was free to choose the ones I wanted to see. The list was chosen by the head of science and included both physics and science lessons for years 9 and above and for a number of different teachers. In all of the lessons I observed, the teacher welcomed me into the class. During the lessons I made notes of my observations (based on the list above) and at the end of the lesson wrote down my overall impression of the lesson including how the girls interacted with each other, with the boys in the class, with the teacher and about their participation in the activities undertaken.

Interviews

Following on from the questionnaire I carried out small, semi-structured group interviews. I originally planned to use three rounds of group interviews as my main data gathering tool for the case studies. The first of these group interviews was used to talk to the chosen girls about their subject choices and what influenced them to make those choices (see appendix 6 for interview schedules and Chapter 6 for more details about the interview process). The second round of interviews focused on teaching and teachers in both physics lessons and the girls' favourite lessons and the third round of interviews on identity and self efficacy and the nature of physics.

Active interviewing

A semi-structured interview can be used to obtain descriptions of the life world of an interviewee with respect to interpreting the meaning of the described phenomena (Kvale, 1996). Interviewing is not now seen as an interviewer 'mining' an interviewee's knowledge without any interaction. Holstein and Gubrium (1995) present the case for the active interview. They say:

> Both parties are necessarily and unavoidably active. Each is involved in meaning-making work. Meaning is not merely elicited by apt questioning nor simply transported through respondent replies – it is actively and communicatively assembled in the interview encounter. Respondents are

> not so much repositories of knowledge as they are constructors of knowledge in collaboration with interviewers.
>
> Holstein and Gubrium, 1995, p17

Opponents of this idea of interaction between the interviewer and interviewee cite that this active approach to interviewing can introduce bias into the responses and data gathered. Holstein and Gubrium counteract this by saying:

> The active approach to interviewing might seem to invite unacceptable forms of bias. This criticism only holds, however, if one assumes a vastly restricted view of interpretive practice. Bias is a meaningful concept only if the interviewee is seen to possess preformed, pure information. But if the interview responses are seen as products of interpretive practice, they are neither preformed nor pure.
>
> Holstein and Gubrium, 1995, p18

Rapley (2007) puts it more succinctly:

> Interviewers should not worry about whether questions are too leading – they should just get on with it.
>
> Rapley, 2007, p16

It was important, therefore, that I was aware of my part in these group interviews. Not only was I the person asking the questions, but I was interacting with the responses that the interviewees gave and trying to develop these responses by asking further questions. My position as an interviewer needed to be thought about at all times.

Semi-structured interviews can be carried out as one-one or in small groups. I chose to use small group interviews rather that one-one interviews for a number of reasons. Group interviews are polyphonic in nature; they allow for a broader spectrum of respondents opinions than one-one interviews (Frey and Fontana, 1991).The groups formed here were not of unknown people but were of groups where, if not friends, then each group member would at least know the others.

This allowed the interviews to be more discussion based than just question and answer (Bohnsack, 2004). Working in groups rather than one-one means that there is not as much pressure on the relationship between the interviewer and the interviewee. A group can provide prompts to develop the talk when participants agree, disagree and respond to others (Macnaghten and Myers, 2007). The group allows the interviewer to identity a range of issues but also to understand how those issues are discussed in the group (Hennick, Hutter and Bailey, 2011). Group interviews have been said to offer some respondent triangulation (Denscombe, 1995) where events and attitudes are subjected to peer scrutiny. However, this aspect can also lead to some of the participants dominating the discussion and others being 'lost'. The interviewer has to work to ensure that this does not happen. I also chose to use group interviews rather than one-one interviews because of the age of the girls. I felt that girls of this age would be more willing to share their thoughts and feelings about a subject in a small group with their peers rather than in a one to one situation with an, at first, unknown adult.

Interview sampling and conduct

Girls were selected and then asked to take part in the small group interviews based on their questionnaire responses.

At Browning School,[18] 37 year 9 girls and 56 year 10 girls completed the questionnaire. Of these, 20 girls in year 9 and 29 girls in year 10 agreed that they would be willing to take part in the small group interviews if asked to. Girls were then selected from those who had agreed to be interviewed (for full details of interview group selection see Chapter 6).

At Hinton School,[19] 52 year 9 girls and 57 year 10 girls completed the questionnaire. Of these 27 girls in year 9 and 33 girls in year 10 agreed that they would be willing to take part in the small group interviews if asked to. Again

[18] For more details about the school see Chapter 5.
[19] For more details about the school see Chapter 5.

girls were selected from those who were willing to be interviewed and details of these girls are given in Chapter 6.

During the first round of small group interviews, issues around the chosen groupings arose at Browning School. The first of these was to do with numbers in the group due to absences, but since this still left groups of three or four I went ahead with those girls who were present. The second issue was about the make-up of two groups. When I contacted the school with my interview selections, I did not explain why I had chosen which girls to go in which groups, apart from the fact that they were either year 9 or year 10 groups. On the day, two girls swapped groups because of their other school commitments. This meant that my year 9 *Yes* group now had a *No (no science)* girl in it and that the *No (no science)* group had one of the *Yes*[20] girls in it. Since I was not made aware of this until the first of the changed groups turned up for their interview, I did not feel that I could say no to the interview and reschedule as I was very dependent on the good will of both the girls and the school for agreeing to take part in my research. I therefore made a decision that I would go ahead with these changed groups and see what came out of the discussion.

At Hinton School, for the first round of interviews, the only issue that arose was a couple of pupil absences, but this did not change the nature of the groups, just reduced the numbers in a couple of them.

Interview data processing

For the group interviews, I had decided to record them using audio only and then transcribe them fully and start to analyse them before the second round of interviews. For the one-one interviews I had carried out for my MRes research I had only used audio recording and had found that this was an unobtrusive way of recording the interviews. Therefore for the group interviews I decided to do the same. I decided not to video the group interviews as I felt that this would be

[20] For details of what *Yes* and *No* groups are, see Chapter 6.

intrusive and that the girls, and myself, would not feel comfortable knowing that all that they did in the interview would be recorded visually. I also felt that the knowledge that a video camera was recording could lead to 'performing for the camera' whereas using a small digital voice recorder would be forgotten and that the girls would be more relaxed during the interview.

The process of transcription is both interpretive and constructive (Lapadat and Lindsay, 1999). Transcription can also be thought of as the first process towards analysing the data (Kvale and Brinkmann, 2009). This is due to the many decisions that need to be made about the nature and form of the transcript produced.

For this research project I decided that I would produce a transcript of the recorded interviews that reproduced each spoken word (or at least 90-95% of them) but did not record long gaps of silence or lots of "ums". This gave a predominately denatuaralist transcript (Oliver et al. 2005). I did include any idiosyncratic elements of the speech, however, if I felt that they contributed to the main discussion. These were mainly OKs and Yeahs when the girls were agreeing with what others said, and also the numerous 'likes' that appear to form a major part of young people's speech patterns in today's language.

I am not an audio typist and as Agar said (1996) 'transcription is a chore' (p 153). The main thing that I found difficult was distinguishing between the voices of the interviewees. Identifying a change in voice was easy; it was recognising which of the interviewees it was which was the difficult part. My research questions focus on how self efficacy and identity, in particular, can affect choice. I wanted to be able, over the series of interviews, to track both an individual girl's thoughts and feelings on these aspects as well as any emerging group themes. Therefore, I needed to find a way of transcribing that met these research objectives (Oliver et al. 2005).

Full transcription of the first interviews from the audio recording only did not happen due to this issue around transcription that I had not anticipated, mainly the need to ascribe each quote to individuals. I could not do this from audio alone. This meant a rethink around how I was going to carry out the subsequent interviews and how I was going to overcome my transcription issues.

In order to be able to fully ascribe each quote to each participant when going from the audio to the written, I needed to revise my research method. I decided that for the second and third round of interviews, I would video the interviews as well as audio record them. On reflection, I decided that my reluctance to video the interviews was based on my poor previous experiences of being videoed. Modern video recording equipment is much smaller and more discrete than in the past. I needed to remember that for young people today, electronic means of communication are readily available and readily used in all areas of their lives. They might not be as reluctant to be videoed as I thought. I discuss ethical issues around videoing below.

As discussed above, one issue that remained from the first round of group interviews was being able to identify individual speakers and match up what they said to the transcription. I overcame this by asking the girls to listen back, as a group, to their recording and used a hard copy of the transcript to identify what they said. This was an interesting process in its own right. The girls were, in some cases, surprised at what they had said during the first interview. This ranged from astonishment that they had been able to compose such clear ideas about their future choices to telling me that they had completely changed their ideas about their choices since the interview. I noted all of these comments down. Comments were also made about how they spoke. Many of them were surprised at how often they said 'like' and at how often they spoke in fragments rather than whole sentences.

Member validation or member checks has been defined as 'the researcher's interpretations presented to the subjects of an enquiry for discussion of their validity' (Kvale and Brinkmann, 2009, p325). In this case, I presented the girls with the transcripts of their first interview where only a small amount of interpretation had taken place. Validity has been described in many terms in qualitative research – quality, rigor and trustworthiness to name a few (Golafshani, 2003). In my case, I was using the participants to identify who said what in the first interview. Their comments allowed me to make notes about their perceptions about what they had said and about the reproducibility of their comments. The girls did not deny that they had said what I had transcribed – they listened back to the tapes themselves. What did come out of this process was how what they had said in the interview was 'the truth' at that time but may not be 'the truth' at another time. The talk in the interview captured their feelings and thoughts at the time of the interview, a 'snapshot', but these may not have been reproduced at a different time. This is something to be aware of when analysing the data and building up a picture of the girls' developing physics identity – an identity that also changes with time.

Transcription of the second and third interviews was carried out using a systematic approach. I first of all transcribed from my audio recording, noting down changes in voice. I then watched the video of the interview, ascribed individuals to each piece of transcription and corrected any errors in transcription or missed changes of speaker. If there were still any parts of the interview that I was not sure that I had transcribed accurately, I then went back to the original audio recording and listened to that again. I did not use the video recording to report on visual observations of non verbal interactions that took place during the group interviews. For these interviews, I solely used the video recording as a means of identifying which individual girls said what.

Interview analysis

As I transcribed the group interviews I made notes of recurring themes and themes that I felt needed to be followed up in subsequent interviews. These themes were both deductive themes developed from the research literature (and used to produce the questions for the interviews) and inductive themes that emerged as the interviews were being transcribed. I had originally planned to complete a full analysis of each round of group interviews before the next so that developing themes could be added to the interview schedules if I felt that further detail was needed. Due to the issues around the transcription of the first interview, I did not complete a full analysis of the interviews after each round, but did note down interesting themes as I carried out the transcriptions.

I carried out a full analysis of the three group interviews once they had all been completed. I wrote down themes that were both deductive and inductive. The deductive themes were drawn from the interview questions and the inductive themes emerged as I read through the interview transcripts and my notes from the transcription process. I looked for repetition of topics and used them to produce a code book (see appendix 13), adding to the codes as I moved from one round of interviews to the next. The codes produced were hierarchical. For example the overall theme of yes to choosing physics had several sub codes related to the reason for that choice (e.g. interest, needed for future career, best school subject). I used NVIVO to code all the group interviews. The processing of the data was by 'cutting and sorting'; identifying like quotes and collecting them together (Ryan and Bernard, 2003). Once I had coded all the group interview data in this way, I then reduced the number of themes for discussion by grouping together similar themes. For example, themes relating to self efficacy (feedback, physics ability compared to friends, physics ability compared to class and scored ability for physics) were all combined into one self efficacy theme. Finally I printed out hard copies of all the quotes I had allocated to each theme. I used these to identify quotes to use in the discussion of results (see Chapter 6). The quotes given here were not identified at that stage by individual speaker but just by which interview they had come from to try and overcome any unconscious bias on quote selection; although for the analysis and discussion of findings in Chapter 6 I did allocate names to the quotes so that any trends in data between interview groups could be identified.

Developing Narratives

It was whilst I was transcribing each of the three rounds of group interviews that I first started to feel that there were some individual stories that needed to be told. When reading through the transcripts to identity themes for coding this feeling grew. It was at this point that I decided to see if my initial feelings were correct and I moved into the third iteration of my research by focusing on individual narratives.

Narrative enquiry is increasing being used in studies of educational experiences (Connelly and Clandinin, 1990). Although it is becoming more popular, narrative research is difficult (Squire et al., 2008). Narrative can be thought of as both a phenomenon and a method. People can be thought of as leading storied lives and the narrative researcher not only collects and tells those stories but writes a narrative of that experience (Clandinin, 2006). Narratives have strength in that human existence relies on the synthesis and analysis of narratives that are embedded in a social context (Bold, 2012). Narratives help to define the self and personal identities.

Narratives are coloured by the context within which they are set. Understanding the context is necessary for making sense of the narrative (Clandinin and Connelly, 2000). For example, a child will be influenced by their school, their home life and their peers. Each child is an individual and is influenced by these different contexts and situations in different ways over time. The child is not a universal case that can be fitted into any context and who will perform in a pre-expected way. As Clandinin (2006) says, based on the pragmatic philosophy of Dewey, there are two criteria of experience. Firstly, people are individuals and need to be understood as individuals but always in a social context. Secondly, experiences grow out of other experiences which lead to further experiences. Narratives are therefore not generalisable but capture the contextual influences on an individual in a way that other research methods may not.

Narratives can fall into one of three theoretical categories (Squire et al., 2008). They can be narratives of past events that are more or less constant; they can be experience centred where stories about general or imagined phenomena are explored which vary over time and across circumstances; and they can be co-constructed narratives that develop during conversations and can be shaped by the audience. For the narratives I collected I focused on aspects of the girls' life histories as related to their physics choices. Life history is defined by Watson and Watson-Franke (1985) as:

> any retrospective account by the individual of his/her life in whole or in part, in written or oral form, that has been elicited or prompted by another person.
>
> Watson and Watson-Franke, 1985, p23

Life histories can be thought of as narratives of past events but they are also co-constructed during the interview conversation. Life history research focuses on the individual and how they understand and recall events from their past. The stories we tell about our lives are privileged as well as troubled since they are told in retrospect and have been reflected upon (Bruner, 2004). We tell the truth as we now perceive it, not as it may actually have happened. We are storied selves; we tell stories about ourselves all the time. These stories are the cornerstone of our identities with a close relationship between the stories we tell and hear and who we are (Andrews, 2007). Our personal narratives are, however, not just personal; they draw on cultural norms and the discourses that we encounter in our day to day lives (Sclater, 2007). They allow us to investigate not only individuals' lives but also broader social processes. Narrative can be used to look at whole biographical histories or just at important turning points during life. In these one to one interviews I focused on specific turning points – how the girls came to make their physics choices and what aspects of their life histories contributed to these choices.

When telling a narrative there are several qualities to look for in order to make the narrative a 'good story'. These were identified by Sikes and Gale (2006) as:

a. Liminality – those spaces where a reader opens their thoughts to something new
b. Transgression – allows us to move beyond the actual to make emotional responses to the narrative
c. Evocation – when we are emotionally moved by the narrative
d. Complexity – the narrative interweaves new ideas

e. Creativity – the narrative creates new concepts
f. Audience engagement – the narrative captures the attention of the audience by communicating in a certain way.

(p3)

There is, however, no single way that narratives are analysed to create this 'good story' (Atkinson and Delamont, 2006, quoted in Bold, 2012). Stories generated from interview data are often in a form of a summary of events that have happened rather than a detailed story (Watson, 1976, quoted in Bold, 2012). Czarniawska (2004) stresses that when writing up a narrative, you must be careful not to silence any voices. Narrative research relies heavily on interpretation. The main voice of a narrative will be the subjects, but as the researcher I will also have a voice. Therefore, it is important that I am aware that my voice does not overshadow that of the subjects. Analysis of the text from the interviews (both group and one-one) was a cyclic process where the interviews were transcribed, interpreted and then re-produced as personal narratives. This process continues as the narratives are read by others and feedback is given and they are then reworked. It is important in this process that the voice of the subject is the main one that is heard.

Analysis of narratives is a complex process. During my analysis I identified themes from the interview data, by repeated reading through of the transcripts, which provided an overall story of each girl's relationship with physics. Narratives are not a search for the truth, but acknowledge the personal experiences of each girl as recounted at that moment in time. They are valid and reliable since they are purposeful for the context in which they were generated. To carry out the narrative enquiry I chose to use one to one interviews. I had originally chosen to use group interviews because I felt that the girls would be more comfortable in a group with their peers rather than just being interviewed one to one by someone who, at the start of the process, was an unknown adult. After completing three rounds of group interviews, I felt that I had built up a rapport with the girls and that they would no longer be uncomfortable in a one to one situation. These interviews were also going to look at aspects of the individual's life history and there may have been aspects of these which they would not be comfortable sharing in a group environment (or had not shared already).

For the one to one interviews I used a more structured approach than in the group interviews. The questions I asked were different for each girl and were based on their questionnaire answers and their previous interview responses. The dialogue generated in the group interviews can lead to the creation of a collective narrative rather than an individual one. Here I was giving the girls the opportunity to tell their own version of events, but bearing in mind that they could still be telling the narrative to suit the context; that of a one to one interview with a person who was interested in their relationship with physics. I could not assume that the narrative told in this context would be exactly the same if told in another context; however by using more structured questions I hoped to limit this variability.

I decided that I would not interview all the girls individually but select those whom I felt had stories that would resonate with how girls come to make their choices about whether to study physics post-16 or not (see below for selection process used). I wanted to see if I could identify girls whose identification with physics had changed over the course of the interviews (either to a more positive identification or to a more negative identification) and/or whose identification with physics had been greatly influenced by others (e.g. teachers, peers, parents or society).

In order to select the girls for these one to one interviews I produced a simple spreadsheet with fourteen sections (name, school, year, yes or no to choosing physics (questionnaire and interview), yes or not to choosing other science subjects (questionnaire and interview), reasons for choosing/not choosing physics (questionnaire and interview), physics words from questionnaire, physics self efficacy question answers from questionnaire, physics self efficacy ranking from interview, quotes about physics identity and physics self efficacy from the interviews and finally any other relevant quotes from the interviews). I used NVIVO to collate the data (generate a node) for individual girls from the interviews and printed off transcripts for each of the girls made up from their collective contributions to each of the group interviews. I then entered data from the questionnaire and the collated interview transcripts onto the spreadsheet for each girl. From this spreadsheet I identified five girls whose identification with physics had varied over the course of the interviews and from the original questionnaire and/or whose identification had been greatly influenced by others. I also chose girls who had contributed more than others to the interviews.

Of these five girls I decided to interview four of them one to one. I decided not to interview the fifth girl further for ethical reasons (see below) and also felt that I had a good coverage of her narrative from what she had said in her group interviews. All of these girls came from the same school (see Chapter 7 for more discussion on this issue). On the actual day of the one to one interviews, only three of the girls attended. I decided not to follow up the fourth girl because of times constraints, so ended up with just four narratives to describe and analyse (one taken purely from the group interview data and three from the group interview data supported by their individual interview data).

Ethical Issues

When planning this piece of research, ethical concerns were addressed at all stages. The research proposal was reviewed by the University ethics committee and approval was gained before starting the research. The ethics approval form used followed BERA guidelines (BERA, 2011). The schools identified from the National Pupil Database as possible research centres were all contacted by letter (see appendix 10). One of these schools, Browning School, responded positively to this letter and I visited the school and talked through the project with the Head of Science. I presented the school with a detailed brief which outlined all the components of the, then, case study research (see appendix 11). The second school, Hinton School, expressed interest in participating at a meeting. I again visited this school and talked through the project with the lead practitioner for physics and an assistant head. This school was also presented with the detailed briefing pack. Following this meeting, both schools gave their permission for me to proceed with the project.

The initial questionnaire asked for names so that I could select participants for interview. A statement (see appendices 1 and 2) accompanied the questionnaire stating that only the researcher would see the raw results (which are stored on a password protected file) and that any results used would be annonymised. At the end of the questionnaire, respondents were asked whether they were willing to take part in interviews, and only those who responded in the positive were included in the selection process for the interviews.

Each of the girls selected for the interviews was sent a letter (see appendix 8) outlining the details of the project and assuring them that all material used would be anonymous. I also outlined that if they wished to withdraw from the research project at any time then that was acceptable and no questions would be asked. Participation in the interviews could result in identification of areas of themselves that the participants were not happy to share. The project brief made them aware that they did not need to disclose any information if they were not happy so to do. The consent form (see appendix 9) asked them if they were willing to take part in the group interviews and if they were willing for the interviews to be audio recorded. Before the first interview I checked that they all understood what I was asking them to participate in and again confirmed with them that they were willing to take part. For the second and third round of group interviews I also video recorded the interviews. Further verbal consents were obtained before videoing took place. The three girls who attended the individual interviews were asked verbally to give further consent that I could interview them individually.

Debriefing occurred at the end of each interview when I chatted with each group off the record. The girls were informed that if they wished to read the interview transcripts before they were used in the research they could. Due to the problems with transcriptions, the transcripts from the first group interviews were read whilst the girls listened to the audio recording and annotated the scripts to identify when each of them spoke. Although they were interested in this process, not one of them asked again to read their subsequent transcripts.

The names used for the girls in the project were chosen by the girls themselves. By doing this I allowed them to have ownership of their data with me as we would be the only two people who could match actual people to the reported data. The transcripts of the interview data have been saved on a password protected file. The video recordings have been saved on a password protected computer and the originals deleted from the camera. The audio recordings have also been downloaded to password protected files.

Ethical issues also come to the fore when writing up narratives. As mentioned above, I did not follow up one of my chosen stories with an individual interview (Indiana). The story told as part of the group interview had obviously caused distress to her. I felt that I had enough data to tell her story from the group interviews and did not want to distress her further by going over the story again. As noted above when writing these narratives, I need to be aware that I have considerable power to create a version of reality that is mine and does not reflect that of the researched (Sikes, 2010). An ethical approach demands that I had to endeavour to re-present their lives respectfully.

Chapter 5 The Schools and The Questionnaire Results

Introduction

In Chapter 1, I discussed the participation data for physics which shows that approximately 20% of the A-level entries are for girls. The Institute of Physics (2012) carried out a more detailed investigation of the 2011 data looking at the progression data from GCSE to A-level. This showed that no girls went on to study A-level physics from 46% of the schools.

In Chapter 4, I described how I selected the two schools who participated in my research. These schools were chosen due to their higher than average progression of girls onto A-level physics. In this chapter I describe those schools in more detail. In Chapter 4 I also described the questionnaire. In this chapter I present some of the results from those questionnaires for both schools.

The Schools

Browning School

Browning School is a comprehensive school that is located two miles from the centre of a large town. The school became an academy in 2011. The school has approximately 1300 pupils with just over 300 in the Sixth Form. It has a designated specialist status and was also designated as a Teaching School[21] during the research.

[21] Teaching schools are schools deemed by Ofsted, the government body which oversees quality in education, to be outstanding and that work with others to provide high-quality training and development to new and experienced school staff. They are part of the government's plan to give schools a central role in raising standards by developing a self-improving and sustainable school-led system.

At the time of the research, the science department had a team of twelve teachers supported by four technicians and two teaching assistants. Science was taught in ten laboratories, two of which were designated as sixth form teaching rooms. Of the twelve teachers, three taught physics.

For GCSE the school taught the AQA syllabus. For A-level the Edexcel Salters Horners course is followed for physics. In 2012, 34 students sat the AS physics examinations and 23 the A2 examinations.

The GCSE results for 2012 showed that of the 194 pupils who sat the examinations, 91.3% gained five plus A* - C grades including Maths and English, well above the national average of 58.2%. 94% of these pupils continued into further education, with 72% remaining at Browning School. For Science 90.3% of pupils gained an A* - C for the core GCSE and 86.3% an A* - C for the additional GCSE. Overall the pupils at this school demonstrated a higher than average attainment at GCSE.

Of the 34 pupils[22] who took the AS physics examination in 2012, all but one passed with 13 gaining a top grade. For the A2 examination there was a 100% pass rate with four pupils gaining an A* and a further 7 an A grade. I was not able to access data that showed the percentage of girls in these cohorts or whether they had progressed internally, but comments from staff showed that the majority of their sixth formers had progressed internally.

Ofsted describe the school as a popular comprehensive school. As noted above, it is graded outstanding[23]. They state that most of the pupils are of White British background but that the percentage of pupils from ethnic minorities has increased in recent years. The number of students whose first language is not English is low for a school of this size as is the percentage of pupils eligible for free school meals and those with learning difficulties and/or disabilities.

---

[22] Number of girls and boys not specified.
[23] The highest grade awarded by Ofsted in school inspections.

My survey was answered by 199 pupils. The tables below show the reported ethnicity of the pupils and the reported socioeconomic background of their parents/guardians.

Table 5-1 Reported ethnicity of pupils in survey sample.

Ethnicity	% of pupils in survey sample
White	89
Black	1
Asian	2
Mixed Race	5
Other	3

Table 5-2 Reported socioeconomic background of parents/guardians of pupils in survey sample.

Socioeconomic Grouping	Mother's background (%)	Father's background (%)
Professional	49	47
Clerical	22	11
Senior Official	2	7
Store workers	5	5
Skilled Manual	2	17
Semi-skilled Manual	9	1
Unskilled	3	0
Don't Know	4	8
Unemployed	9	3

This data shows that the majority of the pupils who completed my survey described themselves as White and had parents who came from a professional background. This does not reflect the UK ethnicity or socioeconomic background statistics, so care needs to be taken when comparing data from this school with other schools.

Lesson observations

In my initial request to the schools, I proposed to use lesson observations and informal teacher interviews as part of the data collection methods. Browning School was very welcoming and said that when I was in school carrying out my interviews I could observe as many lessons as I wanted to. Over two separate occasions (see timeline, appendix 14) I observed four physics classes and three chemistry classes[24] ranging from year 8 to year 12.

My overall impressions of the lessons were of well planned lessons with a variety of activities taking place. The teachers were confident in their subject knowledge and were prepared to answer questions from pupils as the lesson progressed. Pupils were mainly on task and participated in the lesson as required.

In the four physics lessons I observed, I took particular note of how the girls in the class interacted with each other, with the boys in the class, with the teacher and how much they participated by asking and answering questions. I also noted how the teacher interacted with the girls and if there was any observable difference between this interaction and that with boys. I observed two year 10 physics lessons, a year 11 lesson and a year 12 lesson. These were given by two different teachers.

The two year 10 classes were on different aspects of the electromagnetic spectrum. In both these classes girls were prepared to put up their hands to answer questions. The teachers chose a selection of pupils to answer the questions. In both classes there were a minority of girls who did not appear to engage with the lesson. One of the teachers tackled two such girls at the end of her lesson and told them that she expected them to participate more fully in the

---

[24] I observed chemistry classes because these were the subjects being taught on the day I was in school and this gave me an opportunity to get an overall feel for the school.

next lesson otherwise notes would be made in their planners[25]. In the other year 10 class, when the group split up to carry out practical work, some of the girls worked in pairs whilst others worked with a boy. In one such girl/boy pairing the girl took charge of the experimental work but in another pairing the girl just scribed. In one question and answer session one boy tended to dominate the session and was asked to respond most of the time; however in another session it was one of the girls who put her hand up and answered most of the questions.

The year 11 physics lesson observed was a preparation lesson for an upcoming GCSE practical assessment. The session started with a question and answer session recapping previous experiments similar to the one being prepared for. Questions were answered by a mixture of pupils. The teacher responded well to a question asked by a girl who did not understand something and he used a good analogy to explain his point. When the practical work started, most of the girls worked in pairs with each other. In one mixed paring the girl carried out the experiment whilst the boy scribed.

The year 12 physics lesson was about collisions and was mainly a practical lesson. There were 15 pupils in this class, five of them girls. Only one of the girls was thinking of continuing onto A2 physics[26]. Three of the girls worked together in one group, whilst the other two girls worked in groups with boys. In the all girl group, the girls worked well together and split up the responsibilities easily. One of the girls in one of the mixed groups was very passive and allowed the boys to set up the equipment and take all the readings. In the other mixed group, the girl was responsible for recording the readings and doing the calculations needed.

At Browning School I also spent time in the staffroom talking to teachers and talked to the teachers I observed following their lessons. All the teachers felt that there was an issue about the number of girls who chose to study A-level physics; they wanted more to take it. Although they had a reasonable number who took

[25] Planners, or diaries, are used in school for students to record their homework tasks and for teachers and parents to record comments about work or behaviour.
[26] Information from informal discussion with the five girls during the practical.

AS, less of them continued on to take the full A-level. For a number of years the school had participated in a scheme to introduce girls to engineering by taking them on organised visits (some of the girls did mention this scheme during the interviews). The teachers felt that this was a positive move towards encouraging more girls to take physics and engineering but described it as a slow process.

The high percentage of pupils who attained high grades for GCSE sciences indicates that prior attainment would not be a barrier to pupils (and by assumption girls) progressing onto A-level physics. In the classes I observed, the majority of girls participated fully in the classes and I did not observe any noticeable bias by the teachers towards the boys (either in asking or answering questions). Overall, I would argue that the prior attainment and teaching observed would not be an obvious barrier to girls taking A-level physics.

Hinton School

Hinton School is a comprehensive school situated on the edge of a large town similar to the town where Browning School is situated. The school became an academy in 2011. The school has approximately 1750 pupils with over 500 in the Sixth Form. It has two designated specialities and it became a Teaching School during my research.

At the time of my research, the science department had a team of twenty teachers and six technicians. Of the twenty teachers, six taught physics.

At GCSE the school offers pupils a choice of three programmes; core and additional GCSE Science; the three sciences as separate GCSEs and a GCSE in Applied Science. At A-level, the physics syllabus delivered is AQA.

The GCSE results in 2012 showed that 99% of pupils gained 5A* - C grades (national average = 79.5%) with 91% gaining A* - C grades including English and maths (national average 58.9%). For science, 90% of the GCSE cohort in

2012 achieved two or more GCSEs at grade C or above. This school, as with Browning School, demonstrates a much higher than national average attainment at GCSE.

The 2012 A-level results show that 57% of the A-level grades were at A*, A or B (national average = 53%). For physics 54 pupils sat the AS examination and 26 the A2 examination. I was able to obtain the breakdown of numbers of boys and girls for this 2012 data (see tables 5.3 and 5.4).

Table 5-3 AS Physics gender breakdown

Student type	Number
Girls (internal progression[27])	9
Girls (external progression[28])	4
Boys (internal progression)	32
Boys (external progression)	9

Table 5-4 A2 Physics gender breakdown

Student type	Number
Girls (internal progression)	1
Girls (external progression)	2
Boys (internal progression)	20
Boys (external progression)	3

For the AS cohort, of the 41 pupils who progressed internally, 22% were girls. Overall, this AS cohort had 24% girls. The national average for girls taking A-level physics is 20%. For this cohort, the total percentage of girls was just above the national average and the majority of these girls had progressed internally. These percentages show that for this cohort, female take up of A-level physics

[27] Studied for GCSE at this school
[28] Entered school in sixth form having taken GCSEs at another school.

was good. The picture is not so good for the A2 cohort. Of the 26 pupils who took the A2 examination, only three were girls and two of these entered the sixth form from outside the school. I do not have the AS figures for this cohort, but it would be worrying for female A-level physics numbers if either this was a true reflection of the number of girls who started the two year A-level programme or there was a high drop out rate between the AS and A2 years.

Ofsted describe the school as a highly popular, mixed comprehensive school which is significantly larger than average. It was graded outstanding. They state that virtually all of the pupils are of White British background. The number of students whose first language is not English is very low, as is the percentage of pupils eligible for free school meals and those with learning difficulties and/or disabilities.

My survey was answered by 259 pupils. The tables below show the reported ethnicity of the pupils and the reported socioeconomic background of their parents/guardians.

Table 5-5 Reported ethnicity of pupils in survey sample.

Ethnicity	% of pupils in survey sample
White	91
Black	2
Asian	1
Mixed Race	3
Other	2

Table 5-6 Reported socioeconomic background of parents/guardians of pupils in survey sample.

Socioeconomic Grouping	Mother's background (%)	Father's background (%)
Professional	49	58
Clerical	21	10
Senior Official	2	7
Store workers	4	3
Skilled Manual	2	13
Semi-skilled Manual	5	1
Unskilled	2	1
Don't Know	2	4
Unemployed	12	2

As with Browning School, pupils at Hinton School are predominantly White and from professional backgrounds. This means that the cohorts of pupils who completed the survey from both the schools are comparable but that they do not reflect the national average.

As I outlined in the section on Browning School, I originally requested that I be allowed to undertake lesson observations and informal teacher interviews as part of my project. Although Hinton School did sign up to fully participate in the project, when I tried to firm up times when I could carry out lesson observations they were not possible. Also, although I was welcome to make a cup of tea and eat my sandwiches in the science staffroom, I did not have the opportunity to talk about my project in detail with the science staff, even though I requested this on several occasions.

The GCSE data from Hinton School shows that there is not an issue with prior attainment being a barrier to pupils progressing onto A-level physics. The 2012 AS Physics cohort data shows that in that cohort there was a just above average number of girls with many of them progressing internally. Headline figures of this type can mask a more complex picture of why girls do and do not choose to continue to study physics post 16. Using a qualitative approach, as I have done, can help to give more details about the reasons for these choices.

The Questionnaire Data

The questionnaire was answered by 458 pupils. The breakdown from each school is shown in table 5.7 below. These pupils were all selected by teachers at each school as having the current attainment needed to achieve a grade at GCSE that would allow them to progress onto A-level physics if they so chose.

Table 5-7 Pupils who answered survey.

	Girls		Boys	
	Year 9	Year 10	Year 9	Year 10
Browning School	37	56	44	62
Hinton School	52	57	65	85

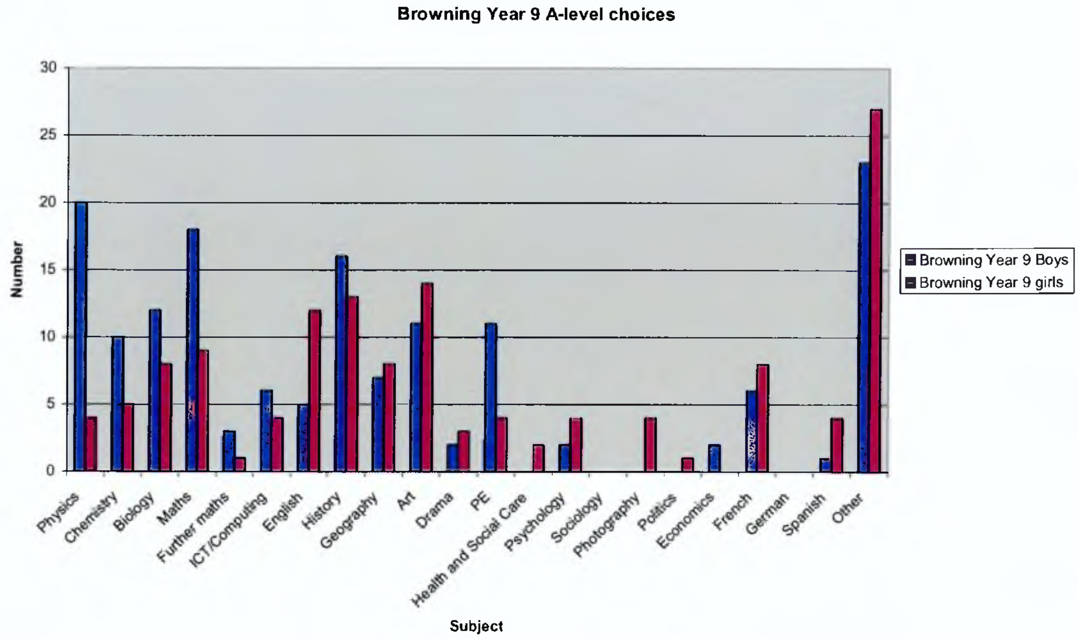
I would have expected that both the year cohorts would include approximately the same numbers (schools tend to recruit approximately the same number of pupils each year). Fewer year 9 pupils at each school completed the questionnaire. This could be an indication of fewer pupils at this age being predicted as having the necessary future attainment to achieve a good GCSE grade or that there was not time for all classes to complete the questionnaire. For year 10 at Hinton School, 18 more boys completed the questionnaire than girls. This could be an indication that there are fewer girls overall in this cohort or that there are more boys in the higher attainment sets. The pupils at each school who answered the questionnaire were chosen by the teachers. Although all the pupils at each school had, in the opinion of their teachers, the current attainment needed to be able to progress onto A-level physics if they so chose, these measures of attainment may be different between the two schools. I would not expect this, but since I did not ask for the measures used, I cannot definitely say that this was not a reason for the different numbers who answered the questionnaire.

The data from this questionnaire give a 'snapshot' view of the opinions of pupils at the two schools at the time the questionnaire was answered. Comparison of pupils is problematic. Comparison of results between the years at each school is also problematic. Observations can be made about the two year groups at the time of data collection but not of changes in opinions from one year to the next.

Possible A-level choices

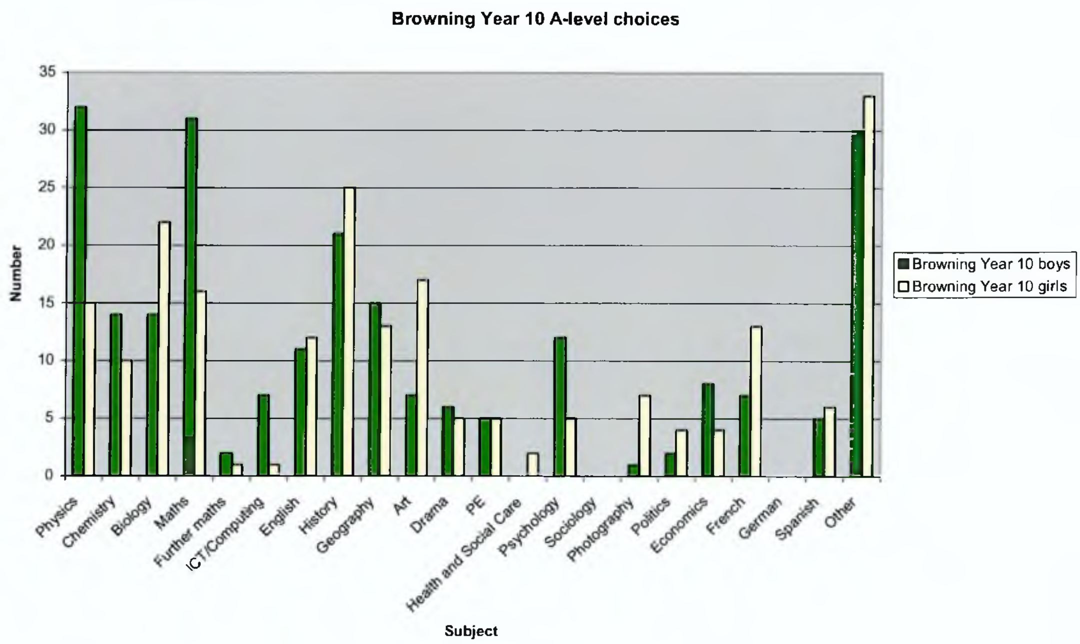
The pupils were asked to list up to five possible subjects that they were thinking of choosing to study for A-level. A wide variety of A-level subjects was selected by the pupils as possibilities. It must be born in mind when analysing these results that these are just possible future choices, not actual ones and that asking about choices in science lessons may have introduced a bias (see Chapter 4).

Chart 5-1



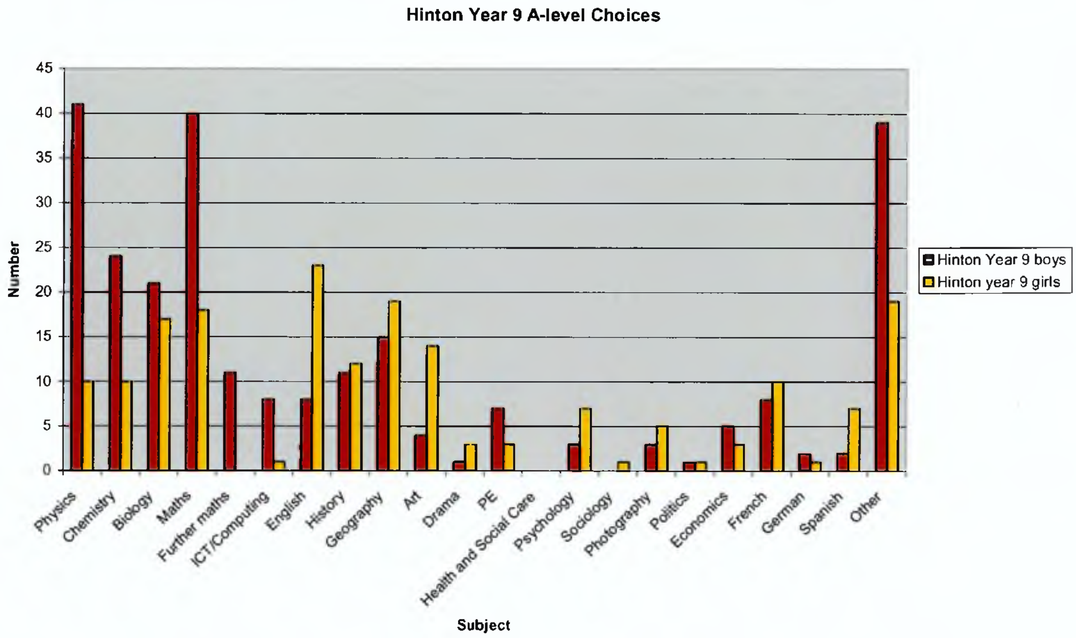
In Year 9 at Browning School 20 boys (45% of boys in the survey) and 4 girls (11% of girls in the survey) indicated that they were thinking of choosing to study A-level physics. It was the most popular future choice for the boys surveyed (not including other subjects) and 9th most popular amongst the girls.

Chart 5-2



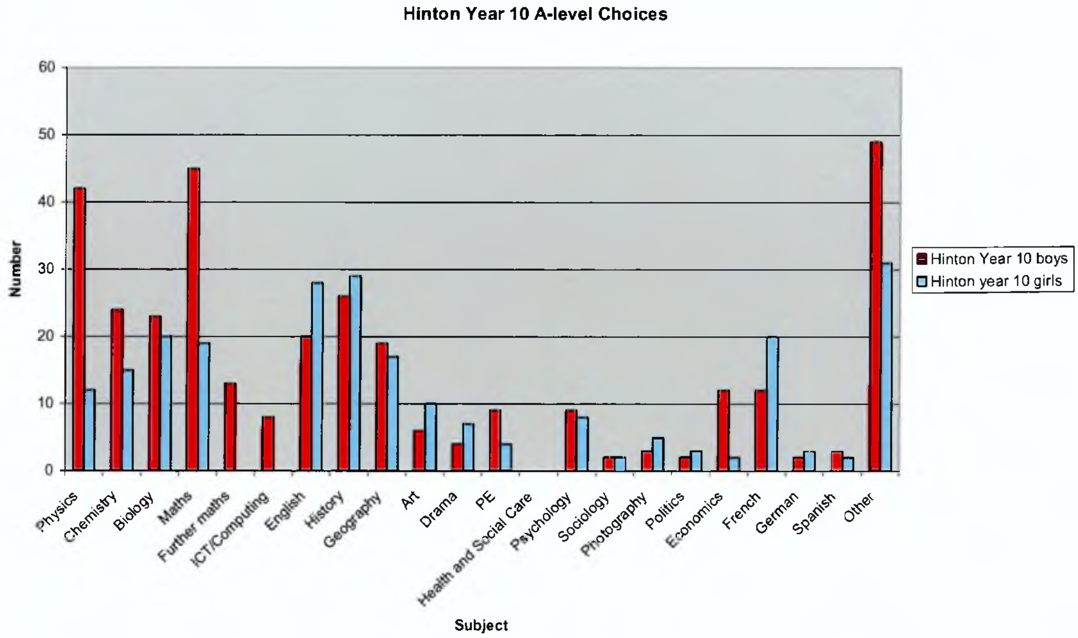
In Year 10 at Browning School 32 boys (52% of boys in the survey) and 15 girls (27% of girls in the survey) indicated that they were thinking of choosing to study A-level physics. It was the most popular future choice for the boys surveyed (not including other subjects) and 5th most popular amongst the girls.

Chart 5-3



In Year 9 at Hinton School 41 boys (63% of boys in the survey) and 10 girls (19% of girls in the survey) indicated that they were thinking of choosing to study A-level physics. It was the most popular future choice for the boys surveyed (not including other subjects) and 7th most popular amongst the girls.

Chart 5-4



In Year 10 at Hinton School 42 boys (49% of boys in the survey) and 12 girls (21% of girls in the survey) indicated that they were thinking of choosing to study A-level physics. It was the 2nd most popular future choice for the boys surveyed (not including other subjects) and 8th most popular amongst the girls.

In 2011 the national picture for A-level uptake (Gill, 2012) showed that physics was the third most popular subject for boys and the 21st most popular for girls (excluding general studies). Overall 10.6% of the A-level cohort chose physics; 18.4% of the male cohort and 4.0% of the female cohort. The figures from my survey are higher than this, possibly due to the criteria used to choose the pupils who answered the questionnaire (i.e. only those who already had the attainment needed to go on to study A-level physics and other A-levels), and these only show possible choices not actual choices. The schools chosen were also ones where there was already a history of high progression onto A-level physics and it has been shown that where there is already a higher progression onto a subject this will be repeated in future years.

Why choose or not choose physics?

The questionnaire asked the respondents to describe why they were thinking of choosing physics or why they were not thinking of choosing physics. Similar answers to this open ended question were coded as one response.

As discussed in Chapter 2, previous research has shown that subjects are chosen for further study because of enjoyment or because they are needed for future career choices. Subjects are not chosen due to low interest (or boredom) or because of poor performance. The reasons given for thinking of choosing or not choosing physics are tabulated below.

Table 5-8 Reasons for Thinking of Choosing A-level Physics

Reasons	Girls		Boys	
	Year 9 (n=14)	Year 10 (n=27)	Year 9 (n=61)	Year 10 (n=74)
Physics is needed for my future career	57	44	36	29
I enjoy physics	29	33	52	58
Physics is mathematics based and I am good at mathematics	0	15	5	1
I am good at physics	14	0	0	4
Choosing physics makes me look good	0	0	5	3
Physics is boring	0	4	0	0
No reason given	0	4	2	5

(Note – figures given are percentage of that cohort)

The two main reasons given for thinking of choosing to study physics at A-level are because physics is enjoyable and because physics is a subject that is needed for a future career goal. Amongst girls who are thinking of choosing physics the most common reason is for a future career rather than an interest in the subject whereas for boys interest is the most common reason. 15% of year 10 girls are thinking of choosing physics because it is a mathematics based subject and they consider themselves good at mathematics and 14% of year 9 girls are thinking of choosing physics because they feel they are good at it. The percentages in both of these categories for boys are much lower. One reason given by a small percentage of boys only was that they considered that taking an A-level in physics gave them kudos – it made them look good compared to other boys because they had chosen a hard subject.

Table 5-9 Reasons for Not Thinking of Choosing A-level Physics

Reasons	Girls		Boys	
	Year 9 (n=73)	Year 10 (n=85)	Year 9 (n=46)	Year 10 (n=73)
I am not interested in physics	27	36	28	42
I don't need physics for my future career	36	31	35	15
I am not good at physics	22	27	9	19
I haven't decided yet what I am taking for A-levels	5	1	22	12
No reason	9	5	7	12

(Note – figures given are percentage of that cohort)

The reasons given for not thinking of taking A-level physics were as predicted by previous research. More girls than boys said that they were not thinking of taking physics because they were not good at it. This could be linked to a lower self efficacy for physics amongst girls than boys (see later section). A reasonable number of boys had not yet thought about what subjects they were going to take for A-level. I have included these pupils in the not choosing physics figures but, of course, they could in the future actually choose physics. I have included them here because at the time of the questionnaire they were not thinking of choosing physics.

Physics words

One of the questions on the questionnaire asked respondents to select from a range of words what they felt about physics. The words were:-

Enjoy	Like	Hate		Bored
	Frightened	Excited		Anxious
Worried	Difficult	Easy	Interesting	

Respondents were asked to select as many as they wanted and to add further words if they wanted. For analysis I recorded how many times each word was selected and allowed up to five words per respondent, which gave an average number of responses. This meant that each respondent could have a different number of responses to this question. I recorded multiple responses and looked for overall trends rather than absolute numbers for each word.

Rather than looking at similarities and differences between the girls and boys in each year group at each school, I looked at the similarities and differences between girls and boys who were thinking of choosing physics and between girls and boys who were not thinking of choosing physics. The words chosen by each of these groups are represented below using a 'word cloud' format (see appendix 4 for data used to produce word clouds). This format shows the most commonly chosen words as larger than those not chosen so often.

Chart 5-5 Girls who are thinking of choosing A-level physics

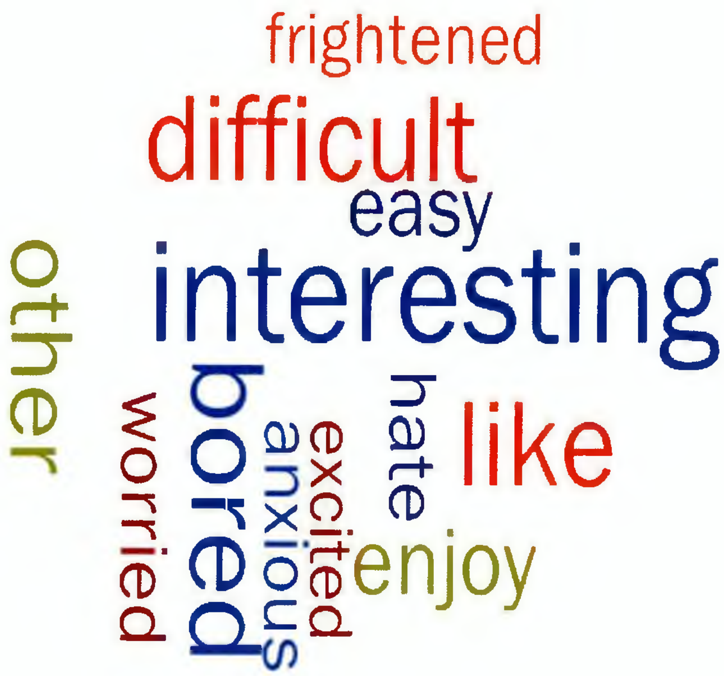


Chart 5-6 Boys who are thinking of choosing A-level physics

For both girls and boys who are thinking of choosing A-level physics their most commonly chosen word to describe how they feel about physics is interesting followed closely by like. However, the girls group also describe physics as difficult more frequently than did the boys group and also felt bored by physics more than the boys. Recent research (Pike and Dunne, 2011) has shown a trend towards choosing physics and some other A-level subjects because they are thought of as being hard and that this gives extra kudos to those students who choose them. The choice of bored is not an obvious one. It could be suggested that bored is linked to easy (i.e. an easy subject does not stretch so you become bored). Another explanation could be that the teaching is not inspiring but this questionnaire will not provide answers for this.

Chart 5-7 Girls who are not thinking of choosing A-level physics

Chart 5-8 Boys who are not thinking of choosing A-level physics

For girls who are not thinking of choosing A-level physics their two most commonly chosen words to describe their feeling about physics are difficult and bored. These are both also chosen by boys who are not thinking of choosing physics but bored was chosen more often that difficult. For both groups of non choosers, many pupils also chose like and interesting.

How do I compare myself to others?

As discussed in Chapter 3, a high self efficacy (a person's perceived capability for learning at a designated level) has been suggested as a good predictor of future subject choice (Britner and Pajares, 2006). Boys are also reported as having a higher self efficacy than girls (Meece and Jones, 1996). One question asking about issues related to physics self efficacy was posed in the questionnaire. This asked the respondents to rank their physics ability relative to the rest of the class and to rank their liking of physics relative to their friends.

Ranking their ability relative to their class reflects the mastery factor of self efficacy; they believe that they are capable of achieving in physics relative to the similar others in their class. Ranking their liking of physics relative to friends reflects that someone often believes that they will be more successful in a subject that they like; they will put more effort in and work harder to achieve.

The results for the statement asking pupils to rate their ability in physics relative to the rest of their class (see below) show that pupils who are thinking of choosing to study A-level physics report a higher self efficacy than those who are not. They also show that boys in general report a higher self efficacy than girls. For girls, year 10 possible choosers of physics report a slightly lower self efficacy than year 9 possible physics choosers whereas the opposite is true for boys. For all groups, except the boys in year 10, there is a small percentage of possible choosers who report that they are amongst the worst in their class for physics.

Table 5-10 Comparing my physics ability to the rest of my class

	Girls				Boys			
	Year 9		Year 10		Year 9		Year 10	
	Y	N	Y	N	Y	N	Y	N
(n=)	14	73	27	85	61	46	74	73
In my class, I am one of the best at physics	21	4	15	2	31	15	53	8
In my class, I am about the same as most people at physics	71	68	81	67	61	70	44	74
In my class, I am one of the worst at physics	7	21	4	19	2	4	0	7
No answer given	0	7	0	12	7	11	3	11

(Note: figures given are percentages for that cohort)

The results for the second statement, asking pupils to rank their liking of physics relative to their friends, show similar results (see below). When asked about liking physics, boys who are possible choosers of physics have a much higher liking of physics than girls who are possible choosers. Again, there is a small group of possible choosers who also say that they like physics a lot less than their friends, and this percentage is higher for year 10 that year 9.

Table 5-11 Comparing how much I like physics to my friends

	Girls				Boys			
	Year 9		Year 10		Year 9		Year 10	
	Y	N	Y	N	Y	N	Y	N
(n=)	14	73	27	85	61	46	74	73
I like physics more than my friends	14	8	33	2	48	9	47	7
I like physics about the same as my friends	79	51	41	52	26	60	32	45
I like physics a lot less than my friends	7	30	15	39	7	23	10	29
No answer given	0	11	11	7	20	9	12	19

(Note: figures given are percentages for that cohort)

Both of the measures reported above (how I compare my physics ability to the rest of my class and how much I like physics compared to my friends) could be used to predict possible choosers of physics. I was interested to see if the same group of students both reported a high belief in their physics ability and that they liked physics more than their friends. For those who were thinking of choosing physics, only 5% of girls (n=41) reported that they both believed that they were one of the best in their class for physics and also liked physics more than their friends whereas 29% of boys (n=135) chose both these statements. Since both of these statements are related to self efficacy, these results show agreement with previous research that for possible choosers of physics boys have a higher self efficacy than girls

Teachers and interest in science or physics

One of the questions asked on the questionnaire was taken from Bennett and Hogarth (2009) and asked respondents to respond to the statement 'my science/physics teachers make me more interested in science/physics' Respondents were asked to agree, disagree or neither agree nor disagree with the statement and then select a further qualifying explanation. (Pupils in year 9 were asked about science teachers and those in year 10 about physics teachers since differentiation of the science subjects did not occur in either school until year 10).

Analysis of this question showed that many respondents had not fully understood how to complete the question as outlined above and had placed ticks in boxes across the range of answers. I recorded these as mixed answers. These responses show a limitation of this type of question where respondents are asked to give one response about all their science/physics teachers. Teachers vary and this mix of answers reflects this variation where pupils may consider that one of their science/physics teachers does/does not make them as interested in the subject as another.

The instructions given with the questionnaires stated that pupils were not required to answer questions they did not feel able to. A high number did not answer this question. This could also be an indication that they either did not understand how to complete the question of felt that they could not make a collective judgment about their teachers in this way. Overall, because of the large number of mixed answers and missing answers, the data needs to be looked at for trends rather than focusing on the numbers.

Bennett and Hogarth (2009) did not differentiate their data by gender or by whether pupils were thinking of choosing to go on to study science subjects at A-level or not. Their sample was of pupils from four schools with 78 year 9 pupils (47% male and 53% female) and 98 year 10/11 pupils (49% male and 51% female). These four schools were all mixed comprehensives and were not selected based on their progressions data. If I use the data just from those pupils who answered the first three statements I have a sample from Browning School of 47 year 9 pupils (57% male and 43% female) and 72 year 10 pupils (51% male and 49% female) and from Hinton School of 63 year 9 pupils (52% male and 48% female) and 82 year 10 pupils (60% male and 40% female). These samples are comparable.

Table 5-12 Comparing my results to Bennett and Hogarth

	Year 9			Year 10		
	B (n=47)	H (n=63)	REF (n=78)	B (n=72)	H (n=82)	REF (n=98_
% of students who agreed that teachers made them more interested in science/physics	74	29	31	54	41	31
% of students who neither agreed nor disagreed that teachers made them more interested in science/physics	15	41	39	31	17	34
% of students who disagreed that teachers made them more interested in science/physics	10	30	30	15	41	35

B = Browning School, H = Hinton School, REF = from Bennett and Hogarth

These results (table 5-12) show that the year 9 pupils at Browning School have a much higher liking of their teachers than those in Bennett and Hogarth's study whereas those in year 9 at Hinton School have a slightly lower liking. For both my schools, the year 10 pupils have a higher liking for their teachers than those in Bennett and Hogarth's study. However, at Hinton School there is also a much higher disliking of teachers. Pupils in year 10 at Hinton School either like or dislike their teachers with only 17% of those included in this sample having a neutral view.

The analysis of my data for this question can be reported differentiated by gender, year group and by whether the respondent was thinking of choosing physics for A-level or not.

Table 5-13 Do my teachers make me more interested in science or physics?

	Girls				Boys			
	Year 9		Year 10		Year 9		Year 10	
	Yes (n=14)	No (n=73)	Yes (n=27)	No (n=85)	Yes (n=61)	No (n=46)	Yes (n=74)	No (n=73)
% of students who agreed that teachers made them more interested in science/physics	21	30	48	19	30	22	45	15
% of students who neither agreed nor disagreed that teachers made them more interested in science/physics	14	16	11	14	20	15	9	19
% of students who disagreed that teachers made them more interested in science/physics	29	8	15	24	10	17	4	25
% of mixed answers	21	38	26	32	33	35	26	32
% of missing answers	14	7	0	12	8	13	15	10

Students who were thinking of choosing to study physics for A-level were more likely, except for year 9 girls, to agree that their teachers make them more interested in science. It was also these groups of students who were more likely to answer this question 'correctly'; they were less likely to give mixed answers or to not answer the question at all.

Science and physics lessons

One of the questions asked was similar to one asked on the UPMAP (Understanding Participation Rates in post-16 Mathematics and Physics) questionnaire (2008) asking pupils to respond to statements about their science/physics lessons. The results are given below for each school year and separated into those pupils who are thinking of choosing physics post-16 and those who are not. This allows comparison in each school year group of what boys and girls who are both thinking of choosing physics and those who are not thinking of choosing physics think about their science/physics lessons and to see if there are any reportable similarities or differences.

Table 5-14 Browning School year 9

	GIRLS						BOYS					
	Yes to physics (n=4)			No to physics (n=32)			Yes to physics (n=20)			No to physics (n=24)		
	A	N	D	A	N	D	A	N	D	A	N	D
I look forward to science lessons	50	50	0	9	72	19	60	15	25	4	70	26
In my science lessons, my teachers explain how science ideas can be applied to a number of different situations	0	75	25	55	29	16	50	20	30	35	48	17
In my science lessons, I have the opportunity to discuss my ideas	75	0	25	55	42	3	55	20	25	36	45	18
I enjoy my science lessons	50	50	0	6	75	19	55	30	15	18	54	27
I learn new skills in science lessons	75	25	0	58	35	6	65	20	15	59	36	5
I enjoy doing practical work in science lessons	50	25	25	81	9	13	90	10	0	71	13	17
I like my science teachers	0	75	25	52	42	6	50	33	17	39	48	13

(Notes: all figures given are percentages. A = agree; N = neither agree nor disagree; D = disagree)

Table 5-15 Browning School year 10

	GIRLS						BOYS					
	Yes to physics (n=15)			No to physics (n=41)			Yes to physics (32)			No to physics (n=30)		
	A	N	D	A	N	D	A	N	D	A	N	D
I look forward to physics lessons	20	73	7	2	51	46	47	44	9	3	47	50
In my physics lessons, my teachers explain how science ideas can be applied to a number of different situations	60	27	13	61	29	10	75	22	3	47	43	10
In my physics lessons, I have the opportunity to discuss my ideas	60	13	27	22	49	29	66	28	6	37	53	10
I enjoy my physics lessons	33	53	13	5	44	51	63	34	3	10	50	40
I learn new skills in physics lessons	67	20	13	32	37	32	63	34	3	43	37	20
I enjoy doing practical work in physics lessons	67	13	20	48	25	28	80	13	6	53	30	17
I like my physics teachers	47	40	13	48	40	13	63	34	3	47	37	17

(Notes: all figures given are percentages. A = agree; N = neither agree nor disagree; D = disagree)

Table 5-16 Hinton School year 9

	GIRLS						BOYS					
	Yes to physics (n=10)			No to physics (n=41)			Yes to physics (n=41)			No to physics (n=22)		
	A	N	D	A	N	D	A	N	D	A	N	D
I look forward to science lessons	10	70	20	7	51	42	29	61	10	9	61	30
In my science lessons, my teachers explain how science ideas can be applied to a number of different situations	10	50	40	10	49	41	32	54	15	39	35	26
In my science lessons, I have the opportunity to discuss my ideas	40	20	40	34	37	29	39	41	20	52	26	22
I enjoy my science lessons	10	80	10	10	61	29	34	51	15	13	57	30
I learn new skills in science lessons	60	30	10	66	29	5	59	27	15	64	32	5
I enjoy doing practical work in science lessons	100	0	0	80	20	0	85	12	2	83	9	9
I like my science teachers	0	50	50	7	63	29	27	59	15	4	70	26

(Notes: all figures given are percentages. A = agree; N = neither agree nor disagree; D = disagree)

Table 5-17 Hinton School year 10

	GIRLS						BOYS					
	Yes to physics (n=12)			No to physics (n=44)			Yes to physics (n=42)			No to physics (n=43)		
	A	N	D	A	N	D	A	N	D	A	N	D
I look forward to physics lessons	8	58	33	2	50	48	46	41	12	21	47	47
In my physics lessons, my teachers explain how science ideas can be applied to a number of different situations	17	42	42	40	29	31	39	39	22	28	43	40
In my physics lessons, I have the opportunity to discuss my ideas	25	33	42	26	37	37	51	17	32	21	53	47
I enjoy my physics lessons	25	58	17	9	37	53	56	32	12	19	50	44
I learn new skills in physics lessons	42	33	25	44	35	21	54	39	7	35	37	28
I enjoy doing practical work in physics lessons	58	17	25	70	20	9	85	10	5	67	30	12
I like my physics teachers	33	42	25	23	44	33	56	27	17	24	37	43

(Notes: all figures given are percentages. A = agree; N = neither agree nor disagree; D = disagree)

The results for girls in year 9 at Browning School cannot be reliably compared between those who are thinking of choosing physics and those who are not since there are only four girls in the thinking of choosing group. For the year 9 boys at Browning School, the thinking of choosing physics group generally have a higher opinion of their science lessons than those who are not thinking of choosing physics. Comparing the two groups of those pupils who are not thinking of choosing physics girls are more likely to look forward to their science lessons, girls think that their teachers explain how science can be applied more often than boys, girls feel they can discus their ideas more often, girls enjoy practical work more than boys and girls like their science teachers more than boys. However, more boys say that they enjoy their science lessons. This liking of science lessons by those girls not thinking of choosing physics could be because they like the non physics parts of science but this cannot be confirmed or denied from these results.

For year 10 at Browning School, girls who are thinking of choosing physics generally have a more positive attitude towards their physics lessons than those girls who are not thinking of choosing physics. The same trend is observed amongst boys. Girls who are thinking of choosing physics also have a more positive attitude towards their physics teachers than boys who are not thinking of choosing physics. This more positive attitude amongst girls intending to choose physics over boys who were not was also observed in the UPMAP work (Mujtaba and Reiss, 2012a and 2012b). The boys who are intending to choose physics have a more positive attitude than girls who are intending to choose physics, again a view observed in the UPMAP work. Amongst those pupils in year 10 who were not intending to choose physics boys generally have a more positive attitude towards physics than girls, except that girls thought their teachers were more likely to explain how physics could be applied to different situations. This was again observed in the UPMAP work. Interestingly, all groups of pupils, except those boys who were thinking of choosing physics, had a similar liking for their physics teachers.

At Hinton School, the year 9 girls who are thinking of choosing physics was again a small group (10 pupils) so comparison of percentages needs to be circumspect. Generally the year 9 girls who are thinking of choosing physics are more positive about their science lessons than those who are not; except that none of the choosing group agreed that they liked their science teachers. The boys who were thinking of choosing physics were generally more positive than the girls choosing group. Amongst the two groupings of boys, those who were not thinking of choosing physics were more positive than the choosing group that their science teachers explained how science could be applied to different situations, that they had opportunities to discuss ideas in the lesson and that they learnt new skills in science lessons.

The responses from the year 10 pupils at Hinton School were more varied. Girls who were thinking of choosing physics reported a more positive attitude than those not thinking of choosing physics for looking forward to physics lessons, enjoying physics lessons and liking their physics teachers. However, the girls who were not thinking of choosing physics reported a more positive attitude to those thinking of choosing physics for saying that their teachers explained how physics could be applied to different situations and for enjoying practical work. For the boys, as expected, those who were thinking of choosing physics had a more positive attitude to physics lessons than those who were not thinking of choosing physics. Boys who were thinking of choosing physics were also more positive than girls who were thinking of choosing, as seen for Browning year 10 and in the UPMAP work. Girls who were thinking of choosing physics were not generally more positive than boys not thinking of choosing physics as seen for Browning year 10 and in the UPMAP work, but were more positive in a few areas (having the opportunity to discuss ideas in physics lessons, enjoying physics lessons, learning new skills in physics lessons and liking physics teachers). Of interest was that all year 10 pupils liked their physics teachers more than year 9 pupils liked their science teachers. Of course, these may not be the same teachers.

Discussion

As noted earlier (Chapter 2) Jenkins and Nelson (2005) found that girls preferred biological sciences over the physical sciences. In the graphs showing possible A-level subject choices, biology was more popular amongst these girls than either chemistry or physics at both schools and for both year groups. For these girls, history, English, geography and Art were the most popular subject choices. This agrees with the findings of Ryan (2011) and Pike and Dunne (2011) where girls are more likely to choose subjects classified as feminine: the humanities and the arts.

The responses to the questionnaire indicated that these girls are more likely to choose physics if it is needed for their future careers. Examples from the literature also show this (Pike and Dunne, 2011; Cleaves,2005; Reid and Skryabina, 2002; Stewart, 1998 and William et al, 2003). Boe et al (2011) also showed that subjects are chosen for further study if they have utility value; they allow access to university courses. Physics can be thought of as a gatekeeper subject so many of these girls may be thinking of choosing physics to help them progress onto more general science based university courses (such as medicine) rather than onto courses with a high physics content. For the boys in my survey, the reasons for choosing physics are not as clear cut. More of these boys are likely to choose physics because they are interested in the subject rather than because they need it for a future career. Not needing physics to help them progress into a future career was the highest reason given by the girls for not choosing to study physics. It would be interesting to find out if the girls in my survey (and generally) develop a career focus for subject choice earlier than for the boys.

Linking to the question about why they were thinking of choosing or not choosing to study physics, the questionnaire asked respondents to choose words that described how they felt about physics. For those girls who were thinking of choosing physics, the most common word chosen was interesting, as it was for the boys who were thinking of choosing physics. The second most common word chosen by the girls who were thinking of choosing physics was difficult. That physics is described as a hard subject links with the commonly held binary dichotomy, as described by Francis (2000), which describes physics as hard, masculine and objective. Even though these girls are thinking of choosing physics, they still hold this generally held conception about physics. For those girls who were not thinking of choosing physics, their most commonly chosen word was difficult. This reinforces the view expressed above and found in the work of Lyons (2006), Bennett and Hogarth (2009) and Pike and Dunne (2011).

As noted earlier (Chapter 3), self efficacy has been found to be a predictor of subject choice (Britner and Pajraes (2006) and some research has shown that boys have a higher self efficacy than girls (Heller and Ziegle, 1996 and Meece and Jones, 1996). The results from the questionnaire show that the boys generally report a higher self efficacy in physics than the girls for each of the questions asked. Since the boys also report a higher percentage of choice to study physics than the girls, it could be deduced that the higher reported self efficacy leads to the higher choice. When combining the two self efficacy measures, the boys demonstrate a much higher self efficacy than the girls. Amongst those respondents who were thinking of choosing physics, the boys reported a much higher self efficacy for the combined questions than did the girls (29% vs 5%).

One question asked the respondents to comment about their science or physics teachers and how much they felt that their teachers made them more interested in science or physics. For Browning School the majority of students felt that their teachers did help them to be more interested in science or physics whereas at Hinton School the responses were more neutral and a higher number felt that their teachers did not help them to become more interested in science or physics. When looking at the similarities and differences between the possible choosers and non choosers groups, generally the possible choosers were more positive about their teachers than the non choosers with the exception of year 9 girls. The influences of teachers on which subjects their pupils will choose to study further has been reported extensively in the literature (see Chapter 2). If teachers help to make their pupils more interested in the subject then they are more likely to choose to study it later. The data from my questionnaire gives some support to this claim. When relating these results to those from Bennett and Hogarth (2009), Browning School showed a higher number of pupils saying that they felt their teachers helped them to be interested in science or physics whereas Hinton School pupils were below the percentages reported by Bennett and Hogarth. The results from my questionnaire may be distorted by the high percentage of mixed answers to this question, but the general trend can be reported. These questionnaire results are supported by the data from the interviews where the girls from Hinton School expressed more variation in teachers and teaching than the girls from Browning School.

In general, the results from the question asking pupils to discuss their science or physics lessons show that they had fairly neutral views about the lessons except for some areas. Browning year 9 pupils in general enjoyed doing practical work in science lessons and felt that they learnt new skills; Browning year 10 pupils again enjoyed doing practical work and also felt that their teachers applied physics to different situations; Hinton year 9 pupils also felt that they learnt new skills in science lessons as well as enjoying practical work but Hinton year 10 pupils only really enjoyed the practical work. Making lessons enjoyable by using practical work was identified by the pupils that Osborne and Collins (2001) interviewed as one of the reasons that they enjoyed science lessons. Pupils overall attitude to physics is another aspect that influences future subject choice (see Chapter 2).

Using the responses from this data highlights some points that teachers and schools need to be aware of if they are trying to encourage more girls (and to some extent more boys) to study A-level physics. Girls are interested in how physics can lead to interesting and fulfilling careers. Information needs to be made available about the variety of careers that studying physics can lead to; either directly or indirectly. Linked to knowledge of future careers, is the generally held understanding that physics is hard, boring and masculine. If the subject itself is perceived as this, then careers linked to it will be too. Efforts need to be made to contradict these commonly held beliefs.

Girls who are thinking of choosing to study physics at A-level generally have a more positive response to their teachers than those who are not. Students at Browning School were more positive about their teachers than those at Hinton School. Positiviness about teachers is a difficult thing to measure, especially when using a tool that asked about science/physics teachers in general, not about specific teachers. The differences between the two schools could just be a factor of the cohorts surveyed and these results may not be reproducible with other cohorts. However, in general, it is important that teachers are aware of the effect they have on influencing students' enjoyment of subjects and their future plans. This will be investigated further in the next Chapter.

The questionnaire attempted to measure the level of physics self efficacy held by the students. In general, boys reported a higher physics self efficacy than girls. A high self efficacy has been linked to subject progression. The link between self efficacy and subject choice is not fully explored in the questionnaire and will be revisited in the next Chapter.

Overall the data gathered from the questionnaire can give a background overview of the attitudes of these pupils to science and or/physics and some of the underlying reasons as to why they are thinking of choosing or not choosing physics. Numbers can be allocated to these reasons and to some of the attitudes expressed about science and/or physics lessons and teachers and physics generally. The data cannot, however, give in-depth information as to why these attitudes are held or why these reasons influence future subject choices. The data cannot also explain subtle differences; for example why one respondent may be thinking of choosing physics but still report that they find it boring whereas another who describes physics as boring is not thinking of choosing to study it further. These subtleties can, however, be explored by asking the respondents to explain their reasons and their attitudes in an interview setting as described in the next Chapter.

Chapter 6 'Do Only Polish Women Choose Physics?'[29]

Introduction

In this Chapter I introduce all forty three girls whom I invited to participate in the group interviews. For each girl I give a brief description based on her questionnaire responses and explain why I chose her to participate in the group interviews. Before describing the findings from the group interviews in detail, I briefly outline the overall themes of the three rounds of group interviews and describe how the interview process developed during each interview and for each round. I then go on to describe the findings from the interviews in detail, grouping the findings based on themes outlined in the interview schedules, on themes based on the research literature reviewed in Chapters 2 and 3 and on themes that emerged during the interviews. I conclude the Chapter with a discussion of the findings.

As described in Chapter 2, Holmegaard et al. (2012) noted research into choices has focused on student background (British emphasis); using choice models to predict choices (US emphasis); and linking choices to identity development (Scandinavian emphasis). A common concern of all is examining what influences these choices. These can include future career aspirations, the influences of family, peers and teachers, and the image of the subject which links into how society views someone who studies that subject. Also in the mix is ethnicity and socio-economic background of the student.

Whilst making choices, we are carrying out identity work. All of the above contribute to how we see ourselves in relation to a subject. As discussed in Chapter 3, our subject self efficacy is intertwined with our identity with respect

[29] At the informal chat after the first group interview, Margery joked that as far as she was concerned only Polish women studied physics since these were the only ones she had heard about; she said that her physics teacher always talked about Marie Curie when he wanted to give an example of a women doing physics.

to the subject and how our subject self efficacy develops impacts on this identity. The identity work takes place within the many figured worlds (Holland et al., 1998) that we encounter during our day to day lives. For the girls discussed below, much of their identity work takes place within the figured world of the school and the figured worlds of the individual subject classrooms.

Introducing the Interviewees

The answers given by girls on the questionnaire were the starting point for selection of participants for the group interviews (as discussed in Chapter 4). All the pupils who completed the questionnaire were also asked if they were willing to take part in the group interviews, and only those who ticked the 'yes' box were included in the selection process for the group interviews.

The initial selection was into two groups – those who expressed an intention of choosing to study physics post 16 and those who did not. I then intended to split those girls who were thinking of choosing physics into two groups depending on what other subjects they were thinking of doing alongside physics as I did in my Masters research (Thorley, 2010). Further selection was done by reading through the responses given to the rest of the questions on the questionnaire. Selection of these girls was not random – for example, I selected those who I felt gave conflicting answers to different questions on the questionnaire; those who felt they were good at physics but who did not want to continue to study it; and those who liked other sciences but now hated physics. Brief descriptions of the forty three girls selected for the group interviews are given below based on their questionnaire responses including details of why they were selected. The pseudonyms used were chosen by the girls themselves.

Browning School

Year 9

Group categorisation	Girls in group
Yes – intending to choose A-level physics	Kathy, Monica, Beryl
No – not intending to choose A-level physics but intending to choose other science A-levels	Louise, Chloe, Heather, Tasmina
No – not intending to choose A-level physics or any other science A-levels	Ivy, Joey, Whitney, Zara
Total	11

In year 9 at Browning School, 20 girls said they would be willing to participate in the group interviews. Of these 20 only three were thinking of choosing physics (in a mixture of A-level programmes) so the *Yes* group was self selecting and I was not able to split it into different A-level programme types.

Kathy

Kathy was thinking of choosing physics alongside chemistry, mathematics, English and photography. She wanted to go into medicine and felt that most universities wanted physics at A-level.

Monica

Monica was thinking of choosing physics as well as mathematics, further mathematics, history and English for A-level. She was thinking of choosing physics because it was her favourite of the three sciences and also because her brother did it and that he made it seem interesting.

Beryl

Beryl was thinking of choosing physics, mathematics, photography, textiles and art for her A-levels. She was not really sure what she wanted to have as a career but felt that physics would be useful to know for any future scientific career.

For those girls who were not thinking of choosing physics at A-level (17), they were split between those who were thinking of taking other sciences but not physics and those who were not thinking of taking science at all. I therefore decided to have two *No* groups to see if there were any similarities or differences in their relationship to physics between girls who were thinking of choosing other sciences and not physics and those who were not thinking of choosing any sciences. I chose four girls for each *No* group. These choices were made by reading through the answers to all the questions on the questionnaire and noting down any interesting quotes (i.e. those that were distinctive or gave an insight into what the girl thought about the subjcet) given for the open ended questions and/or noting down conflicting answers. Selection of the girls for these groups was not a random sample.

Louise

Louise wanted to be a vet or a history teacher so was thinking of choosing a range of science and humanities subjects for A-level. She did not want to choose physics because it was one of the harder subjects for her and she also felt she was one of the worst in her class for physics. I was interested to find out why she did not like physics but did like other sciences – what was it about physics that she felt made it harder than the other sciences and her one of the worst in her class.

Chloe

Chloe also felt that she was one of the worst at physics in her class. She however found biology interesting and was going to choose this for A-level. She thought her science teachers were enthusiastic. Teachers have been identified as influencing future subject choice and I was interested in seeing if Chloe's relationship with her different science teachers influenced how she felt about physics.

Heather

Heather had not chosen physics even though she liked it more than her friends because she felt there were more options in the future if she did the other sciences. I was interested to find out why she thought this.

Tasmina

Tasmina said that she didn't need A-level physics, only biology and chemistry, even though she did not explain why. She again liked physics more than her friends even though when asked to describe how she felt about physics she said that she hated it, it was boring and it was difficult. I felt that if she found physics to be so but still liked it more than her friends, then trying to get girls interested in physics would be a very hard job.

Ivy

Ivy was not going to choose physics because she did not want a job to do with physics. She felt that physics did not excite her and that her teachers did not make it interesting or explain how science could be applied to the real world. I was interested to find out how her relationship to physics was influenced by her teachers

Joey

Joey was going to choose art and textiles for her A-levels. She agreed that science lessons were interesting and that the teachers made the subject interesting. She thought that being a physicist would be interesting and well paid, but was just not for her. I wanted to know why she thought this.

Whitney

Whitney liked her physics teachers and thought that she learned new skills in science lessons and she particularly enjoyed practical work. She liked physics but found it boring and difficult and felt that it was not one of her strongest subjects. I was interested to find out about these apparent contradictions.

Zara

Zara liked her science teachers and felt that she learnt new skills in science lessons. She liked physics and found it interesting. However she was not sure how much she liked physics compared to her friends. Given that she liked physics and found it interesting, why was Zara not thinking of choosing to study physics further?

Year 10

Group categorisation	Girls in group
Yes – intending to choose A-level physics	Florence, Delila, Alison, Livvy, Patricia
No – not intending to choose A-level physics	Kate, Margery, Lola, Eve
Total	9

Twenty nine year 10 girls who completed the questionnaire were willing to be interviewed. Of these, only five were thinking of choosing physics so I selected them all and made one *Yes* group irrespective of overall A-level programme.

Florence

Florence's possible choices for A-level were physics, mathematics, further mathematics and ICT. She was thinking of choosing physics because it was mathematics based and because she wanted to study a science at A-level.

Delila

Delia was thinking of choosing physics, biology, chemistry, drama and history for her A-levels. She wanted a career in medicine so thought that taking all three sciences at A-level would help her achieve this aim.

Alison

Alison was thinking of choosing physics, biology, mathematics, chemistry and geography for her A-levels. She enjoyed physics and thought it would also help her to achieve her career goal; that of being a vet.

Livvy

A combination of physics, biology, chemistry, psychology and mathematics was what Livvy was thinking of choosing for her A-levels. She was thinking of choosing physics because she wanted to take all three sciences to help her in her future career goal, although she did not mention a specific goal.

Patricia

Patricia was thinking of choosing physics because she really enjoyed it, she loved learning about it and found it a very satisfying subject. The other A-level subjects she was thinking of choosing were art, business and design technology.

Of the remaining 24 girls who had all said they were not thinking of choosing physics, only a small number of them had written anything in the open ended questions so this reduced the number of girls I could select *No* groups from. In the end, I decided to have just one *No* group with a mixture of girls who were both thinking of choosing other sciences but not physics and those who were not thinking of choosing any science at all. The four girls chosen for this *No* group are described below.

Kate

Kate was going to choose mathematics and biology for her A-levels but not physics because she was not that interested in the subject. She found physics difficult but interesting. I was interested to find out how she saw the relationship between mathematics and physics and why she was choosing one subject but not the other when they are thought of as being closely linked subjects.

Margery

Margery was going to chose PE, biology and chemistry for her A-levels. She did not enjoy physics lessons and did not like the teacher. She found physics to be boring, was worried about the subject and couldn't be bothered with it. I was interested to find out why she liked the other sciences but, as she said, 'loathed physics with a passion'.

Lola

Lola was going to choose all humanities A-levels because she loved those subjects. She also said that she liked physics less than her friends and thought that it was boring and difficult but sometimes interesting. I was interested to find out why she loved humanities but did not like physics at all.

Eve

Eve was going to choose biology and photography for her A-levels as well as Spanish and French. She thought that physics was a necessary subject and could be interesting sometimes. I was interested in finding out why she described physics as necessary.

Hinton School

Year 9

Group categorisation	Girls in group
Yes – intending to choose A-level physics	Annie, Summer, Josie, Phoebe. Elizabeth
No – not intending to choose A-level physics but intending to choose other science A-levels	Poppy, Scout, Samantha, Jane
No – not intending to choose A-level physics or any other science A-levels	Nora, Ruth, Doris, Ethyl
Total	13

There were 27 girls in year 9 at Hinton School who were willing to be interviewed. Again, only a small number, five, were thinking of choosing physics. These girls formed one *Yes* group.

Annie

Annie was thinking of choosing physics because it was her favourite science subject and also because she did not like biology and chemistry. Her other possible A-level choice was PE

Summer

Summer's possible A-level choices were physics, geography, mathematics and economics. She was thinking of choosing physics because it was her favourite science.

Josie

Josie was thinking of choosing physics because she found it interesting and she thought it would be useful. Also, her sister was taking chemistry for A-level which she now regretted and wished that she had taken physics instead. Josie's other possible choices were French and Italian.

Phoebe

Phoebe was thinking of choosing physics with French, history and English for her A-levels. She was thinking of physics but the final decision would be based on her GCSE results.

Elizabeth

Elizabeth was thinking of choosing physics, chemistry, biology and mathematics for her A-levels. She thought she was going to be a vet so would need all the sciences to help her achieve this goal.

Of the remaining 22 girls, they again fell into two clear groupings as for year 9 at Browning School and the majority of these girls had given answers to the open ended questions so I again selected two *No* groups. This also meant that for year 9 at both schools I had similar grouping for the interviews.

Poppy

Poppy was going to choose biology and chemistry because she needed those for a future career and had not chosen physics because it would not be useful for a future career. She said that she hated physics, found that it was boring and was bad at it. I was interested to see how she compared her ability in physics to her other science subjects.

Scout

Scout was going to choose biology and mathematics but was not choosing physics because she felt that it was too hard. She felt that she liked physics more than her friends, but found it difficult, confusing and that she was anxious about it but she also sometime found it interesting. I was interested to see if she could explain these feelings further.

Samantha

Samantha said that she liked and enjoyed physics and that she found it interesting. She also felt that she liked physics more than her friends. This profile looked like someone who would choose physics so I was interested to find out why she was not.

Jane

Jane had chosen biology and chemistry for her future A-levels. However, although she mainly enjoyed and liked science she felt that it depended on the class and the teacher. She felt that physics was boring, even the practical work and she hated the subject. This made me want to know what she particularly disliked about physics – the subject or a teacher?

Nora

Nora wants to be a psychotherapist so did not feel that she needed physics. She thought physics was boring and difficult and did not see the point of what they were doing in science lessons. I was interested to find out why she was so negative about science and physics in particular.

Ruth

Ruth wants to become an actor or maybe a lawyer. She felt that she was one of the worst in her physics class and that she liked physics a lot less than her friends. She did not think that she was a physics sort of person because she did not like giving only one correct answer. This reason has been given in the past as to why girls do not like physics so I was interested to follow up this comment.

Doris

Doris said that she was not going to choose sciences for A-level because she did not like them but that she would choose mathematics because it was good for jobs. She also felt that physicists were stereotyped in the media. She was the only girl to talk about this aspect so I wanted to include her in my sample.

Ethyl

Ethyl did not really know what she wanted to do for her A-levels and had only chosen politics. However, in her discussion about science teachers she had highlighted that her enjoyment of a subject depended on whether the teacher liked the subject or not. Since previous literature had highlighted teachers as an important influencer of subject choice, I thought she could have something interesting to say on this aspect.

Year 10

Group categorisation	Number of girls in group
Yes – intending to choose A-level physics as part of a science programme	Moa, Emily, Sunnva
Yes – intending to choose A-level physics as part of a mixed programme	Rose, Charlotte, Lily
No – not intending to choose A-level physics	Skye, Anya, Indiana, Ruby
Total	10

Of the 57 girls in year 10 who completed the questionnaire 33 were willing to be interviewed. Six of these girls were thinking of choosing physics; three as part of a science programme and three as part of a mixed programme. Rather than have one large *Yes* group, I decide to have two as originally proposed based on my MRes work.

Moa

Moa's possible A-level choices were physics, mathematics, geography, chemistry and biology. She wanted to study some form of science at university so felt that physics at A-level would be helpful.

Emily

Emily enjoyed physics and thought it would be helpful to her in the future as she wanted to go to university to study science. Her other possible choices were mathematics, geography and chemistry.

Sunnva

Sunnva's father was a physicist and she wanted to follow in his footsteps. She also found physics to be interesting. As well as physics she was thinking of choosing mathematics, biology, chemistry and history for her A-levels.

Rose

Rose's possible choices for A-level were physics, history, French and chemistry. She was not sure exactly what she wanted to do except that it was something science based and felt that physics would help her in this future career.

Charlotte

Charlotte was thinking of choosing physics because she was good at it and she understood it even though it was not necessarily her favourite subject. Her other possible choices were geography, French, mathematics and Spanish.

Lily

Lily thought she would choose physics because it kept a lot of doors open. Her other possible choices were English, philosophy, politics and history.

Since I had two *Yes* groups for this year group, I decided to have just the one *No* group as originally planned. The *No* girls were selected as for previous *No* groups.

Skye

Skye's answer to the question 'are you a physics sort of person' was intriguing. In the answer she explained that she found physics the easiest of the sciences because she felt that she was a logical thinker. She went on to explain that many people did not see how this fitted her as she was also a Christian. An example of two of her worlds not fitting, so something I wanted to investigate further.

Anya

Anya wants to be a musician. She said that she hated physics and found it hard. She felt that this was because she struggled with mathematics and did not like the mathematics aspect of physics. She was one of the few that talked about this link.

Indiana

Indiana was going to choose mathematics, chemistry and product design for her A-levels. These are all physical sciences so I was interested as to why she had not chosen physics as well.

Ruby

Ruby's chosen A-level subjects were a mix of subjects. She felt that physics was boring and difficult and that physicists were more interested in physics than a social life. She also felt that she would not be able to hold a 5 minute conversation about physics without 'dropping off'. Since she had very definite views about physics, I though that it would be interesting to hear more of them.

Summarising the interview groups

From both schools and across both year groups, I had selected nineteen girls who were thinking of choosing to study A-level physics and twenty four who were not. In the *Yes* groups, eleven of the girls said that they were thinking of choosing physics because it would be a useful subject for their future career goals. Seven of the girls mentioned that they were thinking of choosing physics because they enjoyed it, they found it interesting or that it was their favourite science subject. One went further than this to say that she was thinking of choosing physics because she was good at it. Two of the girls said that they were thinking of choosing physics because they wanted to be like a family member; one a brother and one her father. Just one girl mentioned the link between physics and mathematics as the reason for thinking of choosing to study it further.

I split the *No* to choosing physics girls into two groups; those who were not thinking of choosing physics but were thinking of choosing other science subjects and those who were not thinking of choosing any science subjects. Those girls in the *No* to physics but *Yes* to other science subjects groups said that they were not thinking of choosing physics because it was too hard (six); because it was boring (six); and because they did not feel they would have as many future career options if they chose it (two). Two of this group of girls said that they were one of the worst in their class for physics, but four reported that they liked physics more than their friends and one even reported that she enjoyed physics. Three girls in this group related not choosing physics to the teachers; one felt that her biology teacher was more enthusiastic than her other science teachers so she preferred biology; one did not like her physics teacher and one said that her future subject choices were dependent on her teachers.

Girls in the *No Physics, No Science group*s were not thinking of choosing physics because it was not needed for their future careers (two); because they felt physics was boring (three); and that physics was too hard (four). However, one girl reported that she found physics interesting and one recognised that being a physicist could be interesting and well paid but that it was just not for her. Two members of these groups also said that their teacher did not make physics interesting, but two other girls said that they liked their physics teachers.

Details of the questionnaire responses for the interviewees can be found in appendix 5.

Interview Themes and Process

The three rounds of group interviews each had a pre-chosen focus. The first interviews focused on their future subject choices, why they were going to choose or not choose to study physics and what they felt influenced those choices. The second interview focused on teachers and teaching, asking about physics teachers and lessons in particular and then comparing them to their favourite lessons and teachers (if this was not physics). The final group interviews focused on the question 'what kind of person are you?', the girls' relationship with physics and their views on gender and choice in general. I used a semi-structured approach to the group interviews (discussed in more detail in Chapter 4) with a pre-prepared interview schedule (see appendix 6) but during the interviews I allowed the girls the freedom to talk about any topic that came up in the conversation even if it did not directly link to the main theme for that interview. Not all groups talked about the same things and not all members of the group contributed to each line of discussion. Not all of the questions and prompts on the interview schedule were used in each interview as I wanted the interviews to be free flowing discussions rather than structured interviews. This meant that on fully analysing the interview transcripts I found that there were some themes that were discussed in all three stages of the interviews and others that were only discussed in parts of one. Other themes only occurred with some groups whilst others were found in all the groups. Also, some girls talked a lot more than others. This meant some girls are quoted more than others and some girls not quoted at all (see discussion on limitations of data in Chapter 8). The interviews were coded using both deductive and inductive codes (see appendix 13) (see Chapter 4 for details of analysis).

Exploring Reasons for A-level Physics Choices

As part of the questionnaire I had asked the girls to give a reason as to why they were thinking or not thinking of choosing physics at A-level. To start the group interviews, I asked each group to briefly say again why they were thinking of choosing or not choosing physics. For those who were thinking of choosing physics the first reasons given in the interviews were very similar to those recorded on the questionnaire i.e. they were thinking of choosing physics because they were interested in it or they needed it for a future career. The initial reasons given for not choosing physics again mirrored those given in the questionnaire i.e. they were not going to choose physics because it was not interesting, it was boring, it was not one of their favourite subjects and they did not need it for the future.

However, how choices were made and the influences on those choices were discussed in more detail in all the rounds of group interviews and a more complex response emerged. These reasons and influences could be grouped into themes which are outlined below and discussed in more detail in the rest of this chapter.

The first theme discussed is family influences; the influences of both parents and other family members. Coming from a scientific family appears to be a major influencer as to whether to study physics and/or other sciences at A-level. The influence of peers is discussed next; how the opinions of friends play a part, or do not play a part in influencing choices. Teacher and teaching influences are discussed next. Within the figured world of the school, teachers, and the way that they teach, can have a great influence on whether or not girls choose to study a subject post 16. These girls live within today's society. How this society perceives girls who pursue a study of physics can influence these girls' choices. The belief, held by many in society, that physics is for White, middle class males and how this belief can impact on choices is discussed. One part of our identity is our self efficacy. Previous work has shown a correlation between the level of self efficacy and future subject choices. How the girls used self efficacy to influence choice is one of the themes discussed. The final theme discussed is the discourse of achievement. I use discourse of achievement to refer to the desire to achieve high grades, that grades are the only thing that matter and that subjects should be pursued because they will result in achievement of the highest grades not because of interest of any other reason. A few girls who were not thinking of choosing physics commented that they would change their minds if they turned out to very good at it – choices linked to grades rather than interest.

> if I all of a sudden turned out to be a genius in physics (I would choose it)
>
> Margery, Browning School, Y10, No group

One consequence of the discourse of achievement, when combined with a belief that physics is hard, may be to lead girls not to choose A-level physics.

Influences

Four factors that influence subject choices are discussed in this section. Each of these influences is not stand alone; they work together. Within a developing identification with physics and looking at how this identification affects choice, these influences are part of the story; they all combine to contribute to identity work.

Family influences

Many of the girls talked about how their family and especially their parents had an influence on their choices. Parental career or interests influenced the girls. Those girls who reported at least one parent with a scientific career felt their parents were more likely to encourage them to study science as well.
Examples are:

> my dad's like an engineer, he is always trying to push science instead of anything else
>
> Elizabeth, Hinton School, Y9, Yes group

my parents would like me to choose science cos my mum is like a vet and she did all the sciences for A-level

Rose, Hinton School, Y10, Yes mixed group

Many girls, however, reported that their parents, irrespective of their background, were not encouraging them towards certain subjects but were just encouraging them to choose what they wanted. They were being supportive without direction.

my parents don't really mind what I pick, I think they know what makes me happy

Lola, Browning School, Y10, No group

my mum doesn't really like push me to pick a certain sort of profession or certain area to do, she just wants me to do, if you get the best that you can get, in your subjects you are best at

Scout, Hinton School, Y9, No Physics, Yes Science group

Influences by other members of the family depended on whether the participant had older siblings or not. Older siblings who had been successful or not in certain subjects had an impact on subject choice, both to do the same as them (for example, Florence) and to do the opposite of them (for example, Kate).

I am influenced by my brothers....they are a lot older than me........they did maths and physics and one of them is doing software development ......and it interested me

Florence, Browning School, year 10, Yes group

my brother's doing mathematics, further mathematics, physics and chemistry and I wouldn't want to do that

Kate, Browning School, year 10, No group (choosing biology, Russian and geography)

Within the figured world of the family, support for future choices from parents and family members can be a major influence. From their way of talking in the interviews all the girls appeared to feel confident in making their choices, whatever the subject, when supported by their parents in that choice. What was noticeable was that among the girls who had originally expressed that they were thinking of choosing physics for further study, 12 of them reported that at least one parent had a scientific background. Of the girls who were thinking of studying other sciences further, another five reported that they had parents with a scientific background. Girls who were not thinking of studying any sciences did not talk about their parental backgrounds, even though many did mention that their parents were supportive of their subject choices.

That parents with a scientific background are also encouraging their daughters to choose science confirms the findings of Gilbert and Clavert (2003) that showed that women in science had chosen that career because of encouragement from their parents. Similarly, Olitsky (2006) found that students who had parents who were scientists identified with the scientific discourses used in the classroom more than those who did not. These children encountered scientific language within the figured world of the family and so it formed a familiar part of their world as compared to children who did not have this everyday, home exposure to scientific language. The fact that those girls who were not thinking of choosing physics or other sciences also did not mention that they encountered science in the home (because they did not mention that they had parents who were scientists) could mean that a choice to study science was too much of a move away from the world that they knew within their family for them to make this leap. Therefore, could it be suggested that future scientists will only come from those families where science already forms part of the family's figured world?

Further evidence of where the background of the wider family influences choices came from discussions about how brothers and sisters also influenced choice. However, for siblings, the evidence was polarised; either they wanted to do the same as their siblings or they wanted to do the opposite. Holmegaard et al. (2012) mention this conflict between students wanting to make a choice for themselves and wanting to make a choice that is meaningful to their families. For the girls in my project who were going to choose to study physics or science, the influence of their parents was more than the influence of their siblings; they wanted to make a choice that was not only meaningful to them but also meaningful to their parents whether or not this coincided with their siblings choices or not. For the majority of the girls, their ability to choose subjects that were both meaningful to them and meaningful to their parents was supported by them feeling that their parents would support them to make choices that they were happy with.

Peer influences

As teenagers, peer groups can be particularly important to how one's identity develops. As identity develops within a social world we become very aware of how we are seen by other people. Some of the girls felt that their peers offered them support over their choices, and the majority of the girls in the group interviews, irrespective of what subjects they were thinking of choosing, recognised that although the peer group may not have a big influence on their future choices, the support of the peer group for those choices was important.

> they can understand that if you don't enjoy it you're not going to (choose it)
>
> Kathy, Browning School, Y9, Yes group

Many of the girls talked about how they did not feel that they were influenced by their friends. They did not feel that they had to choose the same subjects as their friends and they did not feel that their friends' attitudes towards their choices affected them with that choice.

> I don't think friends affect you that much
>
> Ivy, Browning School, Y9, No Physics, No Science group

> I'm a very like individual person, I don't let people tell me what to do, so if my friends do physics I say great for them
>
> Lola, Browning School, Y10, No group

> I don't think it really has an impact on what you want to do if your friends are like, oh you should definitely do this, well I don't enjoy it, I'm not good at it, it's not going to help me anywhere in life, so what's the point exactly
>
> Margery, Browning School, Y10, No group

However, a few of the girls in year 9 did feel that their friends influenced their choices, or that other people were influenced by their friends.

> all my friends were doing it and it influenced me too
>
> Louise, Browning School, Y9, No Physics, Yes Science group

> I think some of them are there just 'cos their friends are doing it
>
> Ruth, Hinton School, Y9, No Physics, No Science group

This group of year 9 girls were more conscious of how other people saw them or felt that they needed to be with their friends for the support that they offered. In their work in the US, Stake and Nickens (2005) found that girls reported less peer support for their science choices than boys. This work does not allow for the comparison between girls and boys but does indicate that the majority of this group of girls (White, middle class) did feel that they had the support of their peers to pursue the choices that they wanted and that this support was valued by them. For this group of girls, peer influences were not as important as has been previously reported. A small number of year 9 girls, however, did report that they were influenced by their friends and peers and that they only felt comfortable choosing subjects that their friends were doing too; or they recognised that others in their peer group had made their choices in this way. No girls in year 10 made this type of comment.

Support from the wider peer group may have been more variable, as will be discussed in the section about wider social influences. What the girls did talk about more was whether they felt pressured to make the same choices as their friends or not. This again resonates with Holmegaard et al's. (2012) comments about students making meaningful choices for themselves. Most of the girls felt that they were free to make their own choices with support from their parents for these choices.

As we carry out identity work, we come to think we know who we are and who others think we are. The development to becoming less reliant on 'doing the same as others' is an indication of identity work in progress. This identity work is an individual process. Making choices is part of identity work. A small number of girls talked about how they felt their choices were influenced by their friends and these girls were all in year 9. It could be suggested that making these choices at a time when some girls are more influenced by what others think of them, at a time when they feel more comfortable doing the same as others (their friends and peers), is the wrong time to make choices that could impact on their whole future lives. I speculate that the discussion of this by year 9 girls is due to their age and that at this age they are more conscious of how other people see them. This could also be a 'comfort thing'. Being with your friends means that you do not stand out as a different sort of person from the crowd. Your identity is part of the wider social identity of the many. There is not enough data here to confirm or deny these speculations.

Teacher influences

Within the figured world of the school, a figured world that all the girls encountered on a day to day basis and one that played a major part in their overall life world at this time, teachers have a dominant role. The influence of teachers on subject choices is to be expected and that influence was discussed in the group interviews. The main discussion theme for the second round of interviews was teachers and teaching, but the girls talked about teachers and teaching in all the interviews. Talk from all of the interviews was used to look at how teachers and teaching played a part in influencing choice and identity development. Much previous work has looked at how teachers and teaching influence students' attitudes to science and physics (see Chapter 2) and how teachers play a role in developing figured worlds where science and physics identities can develop (see Chapter 3).

The comments ranged from girls saying that they felt their teachers had a large influence on their future subject choices to those saying that they tried not to let teachers have an influence on those choices at all.

> I think choices often are teacher dependent
>
> Charlotte, Hinton School, Y10, Yes mixed group

> I don't really let the teacher influence me that much
>
> Monica, Browning School, Y9, Yes group

Since teachers are such a large part of the figured world of schools, the girls went on to explain this whole range of influence in more detail. Many famous scientists who are interviewed about the reasons they chose to pursue a career in science mention an inspirational teacher who encouraged them to follow an interest in that subject. This point was discussed during the interviews by year 10 pupils. At both schools, year 10 was when the sciences and other subjects started to be taught in separate classes. In year 10 the girls would be more aware of physics as a separate subject rather than one just mixed in with the other sciences. It is not only the teacher's enthusiasm for the subject that can influence students' liking of their subject but how that teacher interacts with the students (Osborne and Collins, 2001; Krogh and Thomsen, 2005).

> I think, like, whenever you get a really good teacher, it is just sparks your interest in that subject and so that's probably why I feel myself being drawn towards those subjects
>
> Skye, Hinton School, Y10, No group

> if you really like your teachers and they make that subject really interesting, like not boring, then you do tend to enjoy the subject more
>
> Alison, Browning School, Y10, Yes group

Of course the opposite can be said for teachers who pupils consider to be poor teachers or who they experience as making their subject boring, a common reason given for not liking science (Osborne and Collins, 2001). This was highlighted by year 9 pupils at both schools. In year 9 pupils are thinking about what options they are going to choose for GCSE (where they can choose a limited number of subjects alongside the compulsory subjects) and so having a poor teaching experience can influence that future choice.

> if you have a really, really awful teacher then you are not going to want to pick that subject
>
> Joey, Browning School, Y9, No Physics, No Science group

> if you don't like the teacher, then you are not really going to bother (with that subject)
>
> Doris, Hinton School, Y9, No Physics, No Science group

How much an individual teacher can influence a student's decision as to whether to pursue a study of that subject further was clearly reported by Annie.

> if I got a bad physics teacher at GCSE then it would probably say whether I would do it for A-level or not
>
> Annie, Hinton School, Y9, Yes group

She very clearly states a relationship between subject choice and the individual teacher. At the moment in year 9 when Annie completed the questionnaire she was thinking of choosing to study physics for A-level (hence being placed in the Yes group for the interviews), but she would change this decision based on the teacher who taught her for GCSE. (The above quote comes from the first group interview when she was still in year 9 and did not know who her physics teacher would be in year 10 for GCSE).

At the opposite end of the spectrum, and falling into a grouping who were concerned not to let teachers influence their subject choices, is Samantha.

> I try and remember that I may only have that teacher for a year, and I try and put them aside and see do I actually enjoy it, even though my teacher doesn't make it that interesting
>
> Samantha, Hinton School, Y9, No Physics, Yes science group

Here it can be seen that Samantha is trying hard to detach her enjoyment of a subject and her possible future choice to study that subject, from the individual teacher. This is a hard process as school and teachers are the main source of information about a subject. Samantha is attempting to distance the teacher from the subject and realise that long term enjoyment of a subject is due to more than just one person's influence.

Choice models of Eccles et al. (1983) and Boe (2012) place enjoyment as one of the main factors contributing to future subject choice. The girls here described how a 'good' teacher could increase enjoyment of a subject and how a 'poor' teacher could lessen their enjoyment of a subject. Whatever the subject, girls talked about how much the teacher influenced their enjoyment of that subject and so their future choices to study that subject further. Some girls mentioned how they tried not to allow teachers to influence them since they may only be taught by that teacher for a short time.

The notion of what makes a 'good' teacher and what makes a 'poor' teacher was not fully explored. Previous research has focused on the types of teaching techniques that physics teachers should use in the classroom to make their lessons more engaging (for example Angell et al., 2004 and Ladubbe et al., 2000). The girls did touch on this, but the responses were very variable. Personal interactions between the teacher and the students can also influence subject choice. Work by Wubbels and Brekelmans (1997) showed that those science teachers who took an interest in their students as people reported those students had a better attitude towards science. The interviewed girls reported that if they liked their teachers, they were more likely to enjoy the subject that teacher taught. Interactions with teachers were also reported when the girls described the giving of feedback, discussed below in the section on self efficacy. Here they felt that if the teacher liked you because your work was good, then the feedback received was more meaningful. Also, if the teacher gave praise, this made the students feel better about themselves. Teachers who pushed students into answering questions when they did not know the answer or who reported student test grades to the whole class were described as intimidating and those whom the students did not like.

Previous research has also focused on how teachers can make the figured world of the science classroom more conducive to students developing positive science identities (for example Tan and Calabrese Barton, 2009a and Shanahan and Niewswandt, 2010). One factor related to how well a teacher can make the subject they teach enjoyable is the specialism of that teacher.

The lack of teachers with specialist science degrees, in particular physics, has been identified by the Institute of Physics (IOP, 2012) as a concern in some schools. Some of the year 9 girls at Browning School discussed how their experiences of being taught by non subject specialists impacted on their enjoyment of that subject and could have an impact on their possible future choices.

> our teacher he really likes biology and he's got to a biology topic and he's like, ooh all about it, but when we are learning physics, it was just like learn this, you've got an exam coming up
>
> Ivy, Browning School, Y9, No Physics, No Science group

Ivy reflects that the teacher's lack of interest in physics, as compared to biology, is being picked up by the students and this in turn makes them think that physics is less interesting. Another aspect of specialism was voiced by Joey.

> He's specialised in the subject, he knows more, so we can ask him more questions
>
> Joey, Browning School, Y9, No Physics, No Science group

Here, knowing that their teacher specialised in a certain area of science meant that Joey felt that she could ask more in depth questions. By implication, if the teacher has expressed a lack of specialism, then this type of question cannot be asked and more in depth knowledge cannot be passed on.

There may, however, be other issues, less to do with the actual quality and extent of the individual teacher's subject knowledge and more to do with how that teacher positions themselves with respect to their subject specialism. This was expressed in another of the year 9 groups at Browning School where Monica also discussed the issues of teacher subject specialism.

> the best science teacher I have had at this school was the teacher we had in year 7, um I never knew whether he was a biologist, a chemist or a physicist, he just didn't say, he would just teach about everything, whereas all the other teachers were like, oh I don't know how to do that, I'm a biologist
>
> Monica, Browning School, Y9, Yes group

Monica's year 7 teacher did not tell the class which of the science subjects he felt he specialised in compared with other science teachers she had been taught by. Not knowing his specialism did not impact on her enjoyment of any of the sciences because she felt that he was able to teach all of them to a high standard. However, as soon as another teacher said 'I don't know how to do that, I am a biologist' this introduced a negativity that was picked up on by the students.

These girls felt that when a teacher declared that they were teaching a subject that they did not feel comfortable with themselves that the message was that they (the teacher) could not make it interesting and enjoyable and perhaps that the teacher did not value the subject, so therefore the girls would not and should not find the subject enjoyable either. For these girls it was not just an issue of perceived lack of subject knowledge (because the teacher had said that they were not a specialist in that subject) but also how the teachers themselves interacted with the subject being taught that influenced how the girls felt about that subject. The girls want to be taught by a teacher who has knowledge, but who also demonstrates an enthusiasm for the subject being taught. If the teacher does not demonstrate a negativity to the subject by declaring that they are themselves not interested in the subject because they are not a specialist, or that the knowledge is only needed in order to pass the test, but instead is positive about the subject and demonstrate that they enjoy it, the girls will pick up on this positivity and respond well to both the teacher and the subject. Negativity will also be picked up and this in turn will have a negative effect on the students. Therefore, it is not just an issue of subject specialism, but how the teacher portrays their attitude to a subject that is important for students' enjoyment of the subject. This is an aspect of the teacher's identity; they are not expressing an identification with science as a whole, but with one (or two) areas of science. This would not be an issue if that teacher only taught the subject that they demonstrated a positive identification with, but, as illustrated above, this is not always the case.

Influence of society

One of the questions asked in the third round of group interviews was about how the girls perceived what society in general thought about physics and the issue of gender equality in the sciences and how this affected their thoughts. The girls recognised that many people in society held stereotypical views about girls and science and about other subjects and careers that were typically thought of as male or female. A similar image is ascribed to mathematics and Mendick (2003) discussed how this gendered discourse made it problematic for girls to identify in any simple way with the subject and so to choose to study it post-16.

General comments were made about these issues; for example, about the generally held view that subjects can be categorised by gender. The girls recognised that these views were held but did not endorse them; they felt that subjects do not have a gender.

> it is just stereotyping, yes there are some subjects that go better with males than females, but if you actually think about it, it is no
>
> Alison, Browning School, Y10, Yes group

> because of stereotyping into other subjects, like girls are expected to take textiles and art and I am not, it is just a generalisation
>
> Margery, Browning School, Y10, No group

They recognised that many in society did still hold a stereotypical view that physics was for White, middle class males even if it was not admitted.

> generally, like, it is still there, even though we don't want to say it, but it is definitely still there
>
> Kathy, Browning School, Y9, Yes group

They also recognised that this view had arisen historically in times when women did not have equal rights with men but that this was changing.

> there is a lot of history coming in here, like women's rights weren't as much….all men who were engineers and stuff……we have got the message
>
> Indiana, Hinton School, Y10, No group

As quoted above the girls were able to talk about stereotypical views of gendered subjects and mainly felt that it was a historical view and not one that they held. They were reflecting that being a 'modern girl' did not fit with them holding historical, gendered views of subjects. If they did mention these views and thought that it reflected that they held them as well, they usually corrected themselves by adding a statement like 'I don't mean that for me'. Baker and Leary (2003) reported that girls they interviewed also made these kinds of 'slips'.

Generally the girls felt that things needed to change and that they were starting to change, but that this change was slow and generational. They were starting to see changes in how they and other members of society perceived the link between gender and subjects and careers. Joey and Ivy, both from Browning School and in year 9 when the research started and both not thinking of choosing physics or any other sciences, clearly expressed this in their comments which reflected the general view. (Due to group formation, these girls were in different groups for the interviews even though they were both not thinking of choosing physics).

Joey said:

> I think it is changing, cos like how little kids, like when they are younger, so stereotypically it would be like the boys would like dinosaurs and space and things and girls would like dolls and things, I think things are changing
>
> I think things are changing cos boys still do like physics, but and girls sort of, you start to get like a split not just between boys and girls, but between ones that like it and ones that don't

Ivy said:

> most of the teachers will probably, were in a world, in a society when girls weren't there meant to do it like that, and I think they have kept hold of that really cos they have grown up with it
>
> but I think it has changed dramatically in the last like 10 or 20 years or something like that, I think it has changed, but I don't think it is ever going to go away
>
> I have never going to an activity and not been asked to do it cos I'm a girl
>
> there are now more jobs available for girls, like, to do what you want and to engineering and things like that
>
> I think women have just learnt that they are capable and have got more confident in things and just ignore men

Girls at Hinton School also mainly thought the world was changing as illustrated by the following extract from the year 9 Yes group.

Int[30]	OK we sort of touched on Phoebe said quite a bit about she thinks the subjects are boys' subjects and some are girls subjects do you think that still holds true or do you think that things are changing
Summer	changing
Phoebe	I think it is still
Elizabeth	I think it is still starting to change sort of
Phoebe	I think it is when you see more girls in uni
Josie	I think it is like in year 7 you see divide against divide and then when you are off to university I don't think that it matters the you are into your subject then that is when it gets better in your class that is just what I think

These examples illustrate how the girls did think that attitudes towards physics by society in general were starting to change. However, they recognised that this was a long and slow process that might never be completely overcome. They recognised that these views were based on historical, generalised stereotypes. They described how attitudes towards girls doing activities that had previously been described as 'for boys' were changing. They described that as more women were seen to have careers in physics and engineering then the next generation of girls would see these as 'more acceptable' careers to aspire to. They recognised that these changes had been taking place over the past years and would continue to do so but that change was a slow process.

The girls felt that the changes were being made at the primary age and gave examples of this. These views could be a reflection of the fact that the majority of the girls interviewed were from the middle class; Archer et al. (2012), working with mainly working class primary school children, found that girls aged 10/11 had already constructed the view that science careers were masculine and incompatible to their feminine identities. Reay (2001), also working in a primary classroom, found that girls even at this young age grouped themselves based on their developing identities. These identities were based on old lessons of gender

[30] Int is the abbreviation I use to describe my part in the group interviews.

relations where it was 'better to be a boy' but also contributed to by class, ethnicity and emerging sexualities. The girls could be grouped, and often described themselves or others, as nice girls (girls who demonstrate conventional femininity and were hardworking and well behaved), girlies (emphasised femininity by maintaining conventional heterosexual acts such as flirting and discussion about who was going out with who), spice girls (demonstrated 'girl power' by making bids for social power) or tomboys (rejection of femininity) although movement between the groups was observed. The 'nice girls' were mainly found to be middle class with working class girls being either 'girlies' or 'spice girls'. Separating themselves into these groups, mainly along class lines, means that there is only a limited space for girls who reject conforming to stereotypical gendered norms to inhabit. As mentioned in Chapter 3, many teachers feel that a good science student is one who is hard working and 'nice'. However, if nice girls conform to standard ideals of femininity this produces identity conflict if they are interested in a subject that is perceived as masculine, e.g. physics.

Linked to these discussions about society in general and the girls themselves holding stereotypical views about genders and subjects and careers was a more specific discussion about physics as a masculine subject and the gendering of school subjects in general. The girls expressed views at both ends of the spectrum; agreeing that physics and other subjects could be classified as masculine and disagreeing that any subjects had a gender attached to them. This is an example of where the girls could talk about being free to do what they wanted and not be pressured by stereotypical views of society as far as careers and what they wanted to study but still hold stereotypical views about the gendering of subjects.

> I would say physics and like business are quite manly, whereas something like art and textiles are feminine
>
> Livvy, Browning School, Y10 Yes group

> I don't see physics as a masculine subject, it's not really, it's just a subject, it doesn't have a gender……. no subject to me seems predominantly a certain gender
>
> Delila, Browning SchoolY10, Yes group

So Livvy, who is thinking of choosing physics, would agree that physics is perceived as a masculine subject whereas Delila who is also thinking of choosing physics does not think that any subject can be classified in this way. This just shows how complex this issue is with even those who are thinking of choosing physics quite happy to categorise it as a masculine subject and not allow this to affect their choice. It was not just girls who were thinking of choosing physics who thought that it was not gendered.

> I don't think it (physics) is a masculine subject, I think it is open to all genders
>
> Doris, Hinton School, No Physics, No Science group

However, girls are still not choosing to study those subjects traditionally classified as masculine even when they now think that subjects should not be classified in this way.

The work of the ASPIRES project (Archer et al. 2013) found that stereotypical images of scientists and what subjects were for boys and which for girls were formed at an early age and that many parents supported this stereotypical image and reinforced it. Messages from parents are important as children are growing up. It is interesting to note here again that the majority of the Yes girls came from families who had scientific backgrounds so the images of scientists being portrayed to these girls by their parents would have been more positive.

Early exposure to science and parental reinforcement of the view that science is for boys was recognised by the girls, several of who made similar comments to Joey about boys experiencing science and physics stuff at early ages. The argument that boys think themselves that physics is for them and that they are better than girls at science, especially physics, was succinctly expressed by Sunnva.

> I think there is always that thing that boys think boys are better than girls within science, as a whole in physics, I would say that is probably the strongest one for that
>
> Sunnva, Hinton School, Y10, Yes science group

Another stereotypical view held about physics by many in society is that women who study it, because it is viewed as a masculine subject, are more masculine, or have a reduced femininity. Emily, from Hinton School, was one of the few girls who was definitely going to study physics at A-level. (Most of the girls who on their questionnaire said that they were thinking of choosing physics did not continue to think this as the interviews progressed). In her group (who were the Hinton School year 10 *Yes* science group) we talked about this aspect of physics.

Int	so Emily you are thinking of doing physics does that make you any less of a woman
Emily	I don't think it does I don't think it does but
Sunnva	I don't think it does I think it makes you a bit more I want to say like almost more independent it sounds really stupid but that's what I automatically think you see a woman and then in a mainly male dominated you know subject and I think it makes a woman seem a bit more powerful and independent I don't think any more masculine but you know I think it your gender is more obvious in a physics class if that makes sense
Emily	especially as some of the boys seem to be more noisier and we stand out more if you are seen as a woman in that type of profession you are sort of showing that you can stand up for yourself
Moa	I don't really know I kind of I don't think it kind of makes you less of a woman but I don't know I didn't choose

physics cos I didn't think I would enjoy it I didn't base it on gender

Emily does not feel that studying physics has any impact on her femininity and also feels that being a woman in a male dominated area gives her power as she stands out from the crowd. Her identification with physics is part of her overall identity work to come to understand what type of person she is.

Mendick's (2003) work looking at post 16 mathematics choices also demonstrates that girls often do not choose to study mathematics because it is seen that a choice to study mathematics is a choice to 'do masculinity'. Choices are part of identity work, so choosing to study a subject considered to be masculine is making a choice to do masculinity as part of your identity. Based on society's views, it is often difficult for girls to make this identity choice, so they choose not to pursue a study of a masculine subject. This is very similar to the choices made around physics. Francis (2010) describes these movements away from a binary description of gender as being part of a heteroglossic gender system where girls can display a macro femininity but with micro masculine contradictions.

On a final positive note, some of the girls talked about how successful women could be if they did choose to study physics; that they should study the subject if they are good at it and that it was not wrong to study it.

> I think women would be good at physics
>
> Sunnva, Hinton School, Y10, Yes science group

> I definitely respect a female in physics, no, I wouldn't think it was wrong at all
>
> Lola, Browning School, Y10, No group

Generally the girls agreed that there is no problem with girls studying physics or taking up a career in physics. They recognised that many in society still held stereotypical views about physics; that it is for White, middle class males.

Although the general feeling was that girls can do physics and that society was changing to accept this view, other voices continued to be expressed; that physics and other subjects were gendered; and that boys were better at physics than girls because of early exposure to the subject at home.

As described at the start of this section, all these influences play a part in a girl's identification with physics. For individuals, one or more of these influences can be more important than others and this will vary from individual to individual. The people who play a part in these influences, parents and family, peers, teachers and society in general, all need to be aware of how they can impact on both a girl's identification with physics and their future subject and career choices. Awareness of the importance of being an influencer can bring about change.

Self efficacy

As described in Chapter 3 self efficacy is a person's self perceived capability for learning or performing actions at designated levels. Four factors have been identified as affecting the level of self efficacy. These are previous performance (mastery experience); seeing similar others carrying out the action (vicarious experience); feedback given on the activity (social persuasion) and physiological states.

In Chapter 3, I also described the link between self efficacy and identity, arguing that self efficacy was just one component of identity. Self efficacy has previously been measured quantitatively, with just a few examples in the literature where self efficacy has been investigated using interviews (Usher, 2009). During the interviews I did not directly ask about self efficacy, but I did refer the girls back to the question they had answered on the questionnaire where they had ranked their ability in physics relative to their class and their friends and asked them to discuss this ranking. Many of the groups also talked about teacher feedback (one factor predicted to affect self efficacy) when discussing teachers and teaching.

Previous performance

The first factor identified in Bandura's (1982) work (see Chapter 3) as affecting the level of self efficacy is previous performance. It has been suggested that a good performance can increase the level of self efficacy and make someone more likely to pursue that activity further. This was the case for the girls.

> I think when you get like a test back or something, and you've got a good grade in it, then you feel like you understand it
>
> Sunnva, Hinton School, Y10, Yes science group

> when I get something right, it makes me like, someone ask me a question and I go, I know that answer to that and everyone is like well done
>
> Margery, Browning School, Y10, No group

Achieving high grades in tests confirms that you have understood the work that was being assessed so gives you more confidence to continue to study that subject further and increase your self efficacy. Feeling good by achieving good test results was mentioned by both Yes and No girls as being important. Margery's comment describes two of the factors that Bandura (1982) identified as affecting levels of self efficacy. These are firstly her mastery of a subject, in that she feels good when she gets something right and that this gives her more confidence to answer more questions. The second factor is feedback from others (see below) and that when other people congratulate her on getting something right it makes her feel good and increases her self efficacy.

Comparison to similar others

The second factor Bandura (1982) identified as having an affect on a person's level of self efficacy was seeing similar others carrying out a task. If these similar others were successful in that task, then self efficacy is increased based on the maxim 'if they can do it, I can too'. At both schools, students were setted by their previous attainment with the implication that all students in any one set should have a similar 'ability' to complete tasks. At both schools the girls described how seeing others in their set being successful actually had a negative affect on them; it decreased their self efficacy.

> I mean in our lessons, the ones who are really, really bright, that can be a bit intimidating
>
> Rose, Hinton School, Y10, Yes mixed group

They did not feel that seeing other members of their set achieving or being able to answer questions in class as being helpful because they saw them as being cleverer than them rather than similar.

> It makes you feel like you are the only one who doesn't get it, if you are in a high set and everyone goes, like I get it
>
> Samantha, Hinton School, Y9, No science group

Related to seeing similar others being successful and not being able to relate to them was the aspect of asking questions in class to clarify understanding. The girls felt that as others in their class already understood the topics being studied, then asking questions would make them appear less able.

> Especially if you are in the highest set, it seems that everyone knows and understands in physics, it is kind of you don't want to ask a question 'cos you think that everyone else knows what they are doing
>
> Emily, Hinton School, Y10, Yes science group

As Shunck and Meece (2005) found, classrooms where the emphasis was on competition and performance goals were ones where self efficacy decreased. The classrooms described here by the girls, show that competition between students and seeing similar others achieve more highly than them did in turn decrease their self efficacy. Competition in the classroom also led to the girls feeling embarrassed that they did not know an answer to a question when asked, and anxiety that they would be asked to answer questions when they did not know the answer. This also weakened the girls self efficacy. This was the same whether the girls were thinking of choosing physics or not. These classrooms were not ones where solidarity with each other and collaboration were encouraged, both aspects identified by Shunck and Meece as being aspects of classroom management that would increase self efficacy.

A comment from Louise combines both the effect of mastery (described above) and comparing yourself to similar others as related to grades achieved in tests.

> I really lose confidence when I hear everyone else's (grade read out)
>
> Louise, Browning School, Y9, No science group

Louise's comment could imply that her own grade achieved could increase her self efficacy if it is considered to be a good grade and as long as she did not just attribute this good grade to luck. The main issue that is decreasing her self efficacy is when this grade is compared to the similar others in her set (class) and if many other students have achieved a higher grade than her, then her confidence and self efficacy decrease.

Feedback

Bandura's (1982) third factor that affects self efficacy is the feedback given on an activity. Negative feedback has been reported (Bandura, 1982) as weakening self efficacy and positive feedback as strengthening it. It was girls who were not thinking of taking physics that talked about the need to receive positive feedback to make them feel that they were on the right track and that they understood the work being done in the class. When they did receive praise from the teacher, it made them feel good.

The main giver of feedback in schools is the teacher. Louise describes how when the teacher gives positive feedback, praise, it can boost her self efficacy.

> when she (the teacher) praises one, you feel like you should get it right, and then when she does and you get it right, you feel really good
>
> Louise. Browning School, Y9, No science group

The teacher can be seen as the gatekeeper to knowledge. Ruth describes how when a teacher gives you positive feedback, then that feedback has weight to it as the teacher is the one who knows that the work is good. Getting positive feedback from a teacher also makes Ruth feel that the teacher will like her more, another positive feedback factor that will increase her self efficacy.

> you kind of want her (the teacher) to like you and say your work is good, cos then you know that it really is
>
> Ruth, Hinton School, Y9, No Physics, No Science group

Informal feedback given during the lesson whilst activities are actually being carried out, rather then once the activity has been completed, can also help to increase self efficacy. They give an immediate boost and allow the student to continue with the activity rather than giving up.

> Sometimes if you need, like, to be reassured that you are doing it right, it would be nice if he (the teacher) could come like over and just say, oh you are doing that right
>
> Samantha, Hinton School, Y9, No science group

Positive feedback from a teacher, either during the lesson or after, can both increase self efficacy and, since it makes you feel good, reduce the feeling that this subject is not for you; improve your overall mindset with regards to a subject. Positive feedback whilst carrying out an activity will also reinforce that effort to continue carrying out an activity is needed and that this, in turn, since carrying on with an activity can lead to achievement, will increase self efficacy.

Physiological factors

The final factor identified as influencing self efficacy levels (Bandura, 1982) is physiological states, for example anxiety, stress and moods. Anxiety and embarrassment were mentioned by the girls and they discussed how this affected their performance in class and their enjoyment of the subject.

Being anxious about not having the knowledge to complete a task can reduce self efficacy. This can also be expressed as not having the confidence to answer questions, either in class or on tests, because the answer is not known.

> I am always anxious that I'm not good
>
> Scout, Hinton School, Y9, No science group

> I'm embarrassed because I don't know the answer
>
> Josie, Hinton School, Y9, Yes group

In the classroom described here the teacher can contribute to a student's anxiousness by insisting that they answer questions. If students are unsure of their level of knowledge, the worry that they will have to answer questions and not be able to provide the correct answer can contribute to levels of anxiety and embarrassment and so further reduce self efficacy.

> she (the teacher) makes you answer, and you just feel more embarrassed, and you feel like everyone's going to laugh at you
>
> Chloe, Browning School, Y9, No science group

Anxiety can also lead to students not being prepared to ask for help when they don't understand the topic being studied. This can cause a spiral of emotions that lead to the situation becoming more difficult to overcome.

> Well the more you don't understand it, the more you switch off, the worse you get, and then you get too scared to ask, and it just gets worse and worse and worse
>
> Anya, Hinton School, Y10, No group

Self efficacy and A-level physics choices

Self efficacy is a complex quality that forms one part of a person's identity. The four causal factors identified by Bandura (1982) as contributing to levels of self efficacy cannot be described totally in isolation to one another as, with the many factors that influence identity development, they are interlinked. The quotes above go some way to illustrating how self efficacy can be affected by interaction in the classroom, both with teachers and with other students, and how levels of self efficacy can fluctuate in a similar way to identity development as described in identity trajectories in Chapter 3.

As with the four influences described earlier in this Chapter, how much each of these factors affect self efficacy is an individual thing. Levels of self efficacy can fluctuate markedly; for example after achieving a high score in a test self efficacy can be high but this can be decreased again if the score in the next test is low. Britner and Pajares (2006) found that self efficacy is a strong predictor for future subject choice. I propose that this needs to be a sustained high level of self efficacy to be directly linked to choice. Since self efficacy is one component of identity, understanding how levels of self efficacy can be affected by Bandura's four causal factors is important to understanding how identification with physics can fluctuate as well. In a classroom situation, the person who has the main impact on self efficacy is the teacher; so it is important that teachers understand the overall impact of self efficacy levels when linked to identity and subject choice.

A discourse of achievement

During the discussion about future subject choices at Hinton School, I identified what I term a discourse of achievement when I analysed the text. This discourse centres on the desire, or the perceived need, to achieve high grades in GCSE subjects, that grades are the only thing that matter and that subjects should be pursued because they will result in achievement of the highest grades not because of interest or any other reason. This discourse is linked to self efficacy (see previous section) but the relationship between the two is complex. Self efficacy describes how one feels about performing in a certain subject whilst the discourse of achievement describes the desire and the need to achieve high grades. This desire to achieve high grades is linked to the messages coming sometimes from government and society in general that it is only grades that matter in the future (for example, the Department of Education's recent statement (2013) that every student will achieve a grade C or above in English and mathematics or they will continue to study them until they do). Subjects are therefore chosen for future study that will give the easiest path towards achieving the high grades necessary for progression into higher education and careers.

Some of the girls discussed how their GCSE grades would influence their future subject choice. Since the introduction of the National Curriculum pupils have had a more limited subject choice at GCSE with most subjects or curriculum areas being compulsory. It is at A-level that the first major choice of subjects is made. Some pupils, in this study, discussed the possibility of basing this choice on grades achieved at GCSE as much as enjoyment of the subject or future career aspirations.

> you want to do well in your A-levels and get good GCSE results, and then more likely to get better A-level results, so you are more likely to take those subjects
>
> Doris, Hinton School, Y9, No Physics, No Science group

most people do pick what they are good at, 'cos there's no point in doing something that you are not good at, otherwise you are just going to be wasting your time

Ruth, Hinton School, Y9, No Physics, No Science group

In later discussions at both schools, girls again talked about how they wanted to achieve good grades in their subjects and about how they felt pressurised to do so. Young people in today's society are often categorised by the grades they achieve in their qualifications. They also describe themselves as being at a certain level or having a certain number of GCSE high grade passes. The primary school children researched by Reay and Wiliam (1999) described how they classified themselves by the level of attainment they were working at (in their case the level they were predicted to achieve in upcoming SATs (Standard Aptitude Tests)). These primary age children 'knew' that they needed to achieve at a certain level in order to be seen as good, academic, students and in order to have good future prospects in both education and careers. If they did not feel that they could achieve the desired levels, they described themselves as 'being hopeless' or 'being nothing'.

Schools and governments also always want to increase achievement and the percentage of pupils who achieve a certain grade in their school examinations. Not only do the girls want to achieve good grades themselves and then pursue those subjects where they will be successful, they feel that they are pressurised by others to achieve good grades. Of course, pressure to succeed can be both positive and negative.

so much pressure that you get anxious, you get really frightened

Kathy, Browning School, Y9, Yes group

there's always been quite a bit of pressure on me to get good grades

Ruby, Hinton School, Y10, No group

> I am predicted all As, but I can tell you that is not going to happen, it makes like so stressful
>
> Doris, Hinton School, Y9, No Physics, No Science group

The pressure to do well was exerted by teachers, by family and by the peer group.

> the teachers put so much pressure on you
>
> Ivy, Browning School, Y9, No Physics, No Science group

> she (my sister) got A stars and then I feel like pressured to try and get as good as her
>
> Ethyl, Hinton School pupil, Y9, No Physics, No Science group

> it is almost like competitive about exam results ......in our year, in our school, is quite competitive and we really want to do well
>
> Anya, Hinton School, Y10, No group

Both schools have an above average GCSE success rate (see Chapter 5 on schools for details). My impression at both schools was that they encouraged the pupils to achieve the highest grades possible in all their GCSE subjects. Both schools ran revision sessions before the examinations using a special timetable. The achievement of good grades was a whole school ethos that formed part of the figured world of the school.

The girls described how they felt that the need to achieve good grades was of great importance and that this message formed a part of the whole school ethos at both schools. In some cases, the requirement to achieve a high grade was seen as more important than enjoying the subject and the pressure exerted by teachers, family and peers to achieve highly caused anxiety (see section on self efficacy above for more discussion about anxiety). The need to achieve good grades also impacted on future subject choice in that girls felt that they should only choose subjects where they could easily achieve these good grades. This need to achieve good grades over and above all other considerations forms the basis of the discourse of achievement.

In Boe et al.'s (2012) discussion about using aspects of the Eccles et al (1983) choice model they highlight five factors that related to STEM choices. One of these is expectation of success. They feel that this is similar to self efficacy but also related to the fact that the physical sciences are seen as hard. Young people want to be successful themselves and in order to be successful will choose subjects that they can see that they will be able to achieve at a high level predicted by previous success.

The discourse of achievement differs from Eccles et al's (1983) expectation of success criteria in that it goes further than an expectation to a need to achieve success at all costs. The discourse of achievement describes not just a hope, an expectation or a belief that choosing to study a certain subject will lead to success, but that there is a need to choose those subjects where success is guaranteed (as much as it can be) based on previous experience and achievement and not on interest and enjoyment.

In her work on mathematics (Mendick (2003)) one of the ways she categorised students who chose to study mathematics post 16 was those who felt they had something to prove to themselves or to others. The discourse of achievement is the opposite of this. In Mendick's work, these students chose mathematics because if they achieved a good grade in a hard subject, this proved, to themselves sand others, that they were capable of being successful in a subject that others considered to be hard. In the discourse of achievement, no differentiation is made between the subjects, whether they are considered hard or soft. All that matters is that the highest possible grade is achieved in any subject. Three other students in Mendick's work, who described themselves as being good at mathematics, chose mathematics because of this. This could be an aspect of choice linked to the discourse of achievement. However, these students also described themselves as liking mathematics. The discourse of achievement centres on a desire to be successful rather than being interested in or liking mathematics.

Discussing the Multiple Influences

The discussion of the analysis of the interview data given above shows how complicated the issue of future subject choices is and the many factors that can influence those choices. In many cases my analysis supports that which has been previously reported. The girls described how they chose subjects they were interested in (Boe, 2012) and those that they needed for future careers (Woolnough, 1994; Pike and Dunne, 2011 and Cleaves, 2005). Students were influenced by their parents (Sajaastad, 2011), most reporting that their parents would support them in making the choices that they were happy with. Those girls who were thinking of choosing physics reported that they were doing so because of direct support from parents who had a scientific background (Gilbert and Calvert, 2003). These girls were also exposed to a family figured world where scientific language was the norm (Olitsky, 2006) so choosing to study physics or science was part of their overall world and did not result in border crossings (Aikenhead, 1996).

The influence of peers was not as important for these girls as has been previously reported (Stake and Nickens, 2005). These girls did not feel, in general, that they were influenced by their friends in the subject choices they made, but that peer support for those choices, once they had been made, was important. A small, but significant, group of girls who did feel influenced by their friends were all from year 9.

As has been previously reported (Angel et al., 2004 and Ladubbe et al., 2000) the teachers whom students consider to be 'good' increase enjoyment of a subject and this leads to possible future choice. These are teachers who 'teach with enthusiasm' regardless of their actual subject specialism. One aspect of teachers not reported before, but that did have an impact on year 9 girls from Browning School, was the subject specialism of the teacher. The impact was not only to do with the subject knowledge but how the teacher described their own poor relationship with the subject outside of their specialism, which was often physics. When teachers displayed that they themselves did not enjoy the subject they were teaching, this negativity towards that subject was picked up by the girls. The girls felt that they were not able to discuss in depth topics or ask for help from the teacher due to a perceived lack of knowledge, and that they also were not inspired to enjoy the subject because of the teacher's lack of enjoyment. However, as one girl described, if the teacher taught with enthusiasm and did not report that they were teaching out of their specialism, there was not an issue.

The stereotypical image that physics and physicists are dominated by White, middle class males is a view that is held by many in society (Ryan, 2011). The view given by Margery that only Polish women can work in physics shows that although women have worked in physics by only using Marie Curie as an example gives a narrow image of the women who have done so. When questioned about this stereotypical view, the girls reported that they were aware of this but that they felt that changes in society's view of what girls could and could not do for careers and subjects that they could study were changing, albeit slowly. However, when they talked about this in more depth, many other voices were present – that physics is still considered to be a subject for boys (Francis, 2000), that girls who study physics are less feminine (Breakwell et al., 2003 and Cleaves, 2005), and that boys themselves consider that they are better at physics than girls from an early age (Archer et al., 2013). These conflicting voices were all heard as part of the identity work being carried out by the girls in the interviews.

One of the reasons given that many students, boys as well as girls, do not choose to study physics post-16 is that it is considered to be a hard subject (Bennett and Hogarth, 2009 and Pike and Dunne, 2011). My analysis found that a further issue linked to this was what I describe as the discourse of achievement. The discourse of achievement describes the desire to achieve high grades in GCSE subjects, that grades are the only thing that matter and that subjects should be pursued because they will result in achievement of the highest grades not because of interest. That physics is considered to be a difficult subject in which to achieve the high grades needed to be successful in future life was a reason for not choosing it.

I have proposed that self efficacy is one component factor of identity. Levels of self efficacy can fluctuate depending on four causal factors (Bandura, 1982). When discussing how they felt about physics the girls reported that they felt better (had a higher self efficacy) when they had achieved good test scores and when they received positive feedback from their teachers and that their self efficacy was lowered by poor feedback and when they were anxious. This was as previously reported (Schuink and Meece, 2005). However, success by comparison to similar others, in the competitive atmosphere of the physics classroom being experienced by the girls, was not something that increased self efficacy as proposed by Bandura; in fact most girls reported that their self efficacy was decreased when they compared themselves to the similar others in their classes.

At the start of this research, I proposed to investigate how physics identity and physics self efficacy impact on future subject choices. The literature interrogated in chapters two and three described a range of factors that have been found to influence choice and identity work. These influences (parents and family, peers, teachers and teaching, and the image of physics) along with self efficacy (a component part of identity) and a discourse of achievement have all been used as themes with which to analyse the data gathered during small group interviews with girls in years 9 and 10 who were both thinking of choosing physics post-16 and those who were not. Much of the analysis has supported previous findings but new factors have also been identified, namely the discourse of achievement and the importance of teacher subject specialism. It was also found that expected differences between possible choosers and non-choosers, as predicted from the questionnaire data presented in chapter 5, were not so obvious when discussion took place. Getting a complete picture of how physics identity and physics self efficacy contribute to choice decisions was also not clear when using the group discussion data. The importance of these was starting to emerge. Moving towards a focus on the narratives of individual girls would, hopefully, give a clearer picture of how identity and self efficacy do impact on choice. These individual narratives are presented in the next Chapter.

Chapter 7 Narratives of Identification with Physics

Introduction

In the previous Chapter, the thematic analysis described how different factors could influence a girl's decision to choose or not to choose to study physics post-16. However, what they did not do is offer a picture of the complexity of how each of these factors could influence any one girl; how these influences worked together, or in opposition to each other, to result in how an individual made their physics choices.

In this Chapter I look at the narratives of four girls from Hinton School. They allow a more in depth investigation of how girls' identification with physics develops and changes over time. I use identification to describe every relationship with physics whether it is a positive identification or a negative identification sometimes termed a dis-identifcation. These narratives are of course not generalisable. They are constructions about specific girls who are learning about themselves and developing their identities and their identification with physics during their secondary school years. However, I believe that these narratives will be familiar to us, at least those of us whose own experience of education is in the UK. We will recognise in the narratives girls whom we know or, if we have been teachers, whom we may have taught; and we may even recognise ourselves, or aspects of ourselves, in their narratives too.

Each narrative looks at one particular girl's journey towards making a choice as to whether to study or not to study physics post-16. They look at how the influencing factors discussed thematically in the last chapter come together in that individual's identification with physics and how they impact on the choices made. Before presenting the narratives I build on the discussion in Chapter 4 to describe in more detail the interview process and analysis that resulted in the narratives.

Interview processes and analysis

It was whilst I was carrying out the second round of group interviews that I started to notice that some of the girls involved had individual narratives that seemed to vividly illustrate how girls develop an identification with physics and how they interact with the figured world of science in general and physics in particular. After completing the third round of group interviews, I used NVIVO to collate all the quotes made by individual girls from each of the three group interviews. Using these collations and a simple spreadsheet (see Chapter 4), I identified five girls whose narratives appeared to me to describe key different ways that identifications with physics develop and change over time.

They were all girls from Hinton School. This outcome was unexpected. When I had collated the information from each of the three rounds of group interviews for each individual girl onto the spreadsheet described in Chapter 4, I hid the columns showing name, school and year group before I made my selection. When I discovered that all the girls came from the same school, I questioned this outcome. This was not a conscious choice on my part, but did my subconscious come into play? I did not choose girls from Hinton School because it was nearer to my home (I enjoyed my trips to another part of the country when I visited the other school), nor because these girls were easy to access (in fact it took over a term once the choice had been made before I was able to interview the girls again). By the time I made this choice, I was immersed in my data and knew the individual girls well and so, therefore, I may have made an unconscious choice. However, if this was an unconscious choice it was not for any obvious reason, for example, I did not feel that I chose these girls because I felt that I could talk to them easily (I would say that there were other girls at both schools with whom I had built up a better rapport). The fact that all these girls came from the same school could be just that these girls were able to articulate about their relationship with physics more than other girls either from the same school or from a different school. The school they attended could be an influencing factor to them having more to say but this would need to be investigated further in order to draw this conclusion. All I can say is that this was not an intentional choice.

I approached four of the identified girls by letter and asked them to take part in individual one to one interviews. They all agreed to be interviewed, but only three of them attended the interviews on the designated day. For the fifth girl, I felt that talking to her again might be too painful and so ethically I did not feel that this would be of benefit; I already had enough detail to write her narrative.

Three of the narratives tell of girls who at some time during their journeys towards A-level choices thought that they would choose physics. At the time of their individual interviews, I already knew that they were not going to choose physics, even though they were all capable of doing so and had thought about it at some point. In fact none of them did and their narratives look at why. The fourth girl indicated on her questionnaire that she was not thinking of choosing physics but was thinking of choosing other sciences. At the time of her individual interview, she had still not made her final A-level choices.

These four narratives are described and discussed below. I start with Rose, who by the time she made her final A-level choices was focused on the subjects she would need to progress to her chosen career. These did not include physics, even thought she was a very capable physics student. The next narrative tells of Indiana's relationship with physics and how one incident greatly impacted on her identification with physics. Charlotte's story describes a girl who, in some ways, 'ticks all the boxes' about what a good physics students should be but she still did not choose to study A-level physics because she enjoyed other subjects more. The final narrative is that of Scout. I'm still not sure how to fully describe Scout's relationship with physics (or science). Her's is the most complex story.

Rose

Rose was a year 10 pupil at Hinton School when I first met her. On her questionnaire she indicated that she was thinking of taking A-level physics along with history, French and chemistry so I selected her as part of the *Yes* mixed group[31]. On her questionnaire her reasons for thinking about choosing physics were that she was interested in a career in science but had at that time not decided what she wanted to study, but since physics and chemistry were her best sciences she was considering them both. Her reasons for choosing history were that she enjoyed it and that it would be a break from the work of her other A-levels and for French that she wanted to live in France in the future.

When asked to select words that described how she felt about physics Rose chose 'enjoy', 'like' and 'interesting'. She felt that she was about the same ability as most people for physics but that she enjoyed it more than her friends. She thought that she might be a physics sort of person because 'I enjoy physics and am not too bad at it'.

Rose described herself as being White and both her parents as being professional. During the interviews she said that her 'mum' was a vet and that she had taken all sciences for A-level and that her 'dad' now worked in environmental engineering working especially with flood defences. She talked about how she had lived in the countryside when she was younger and spent a lot of time playing with her three brothers and their friends. When I asked the girls to describe themselves in the third group interviews Rose described herself as energetic, generally bubbly and as caring a lot about things and people. She felt that in school she wanted to please all her teachers and worked really hard in order to do this

At the start of the group interviews Rose was just completing year 10. By the time I interviewed her individually she had just completed the first term of her

[31] *Yes* mixed group – girls who are thinking of choosing physics as part of a mixed A-level programme

AS year (year 12). Over the five terms that I got to know Rose, she matured into a very confident young woman. She always came to the interviews willing to participate fully and spoke in a clear, articulate manner. She often wore large flower clips in her longish blond hair. At the final interview, where as a sixth former she did not have to wear school uniform, she wore up-to-date, stylish and feminine clothes. This could be interpreted as Rose performing popular heterofemininity to balance out her scientist aspirations as Archer et al. (2012) saw in their 11-12 year old girls. This is a performance to become accepted by her peers who may have little or no interest in science and see girls who do have an interest in science as being less feminine than them (Breakwell et al., 2003). Performing, or even over performing, highly feminine traits, such as the fashionable cloths and hair ornaments, can help to balance out the perceived drop in femininity due to her interest in science.

Rose's initial focus on choosing A-level subjects was to meet her aspiration to have a future career in science. In the first group interview she was fairly vague about what science career she wanted, although she did know that she wanted a career in science whatever the role was.

> maybe chemistry cos I quite like science and I feel like I want to do a science at least at sixth form and chemistry or physics, they are my best two sciences...........I would quite like to be a scientist. I'm not really sure; I change all the time what I want to do but at the moment I want to be a I would quite like to do some form of science
>
> Group interview one

By the time of her individual interview, Rose had chosen her A-levels around the fact that she wanted to go on and study medicine. For her A-levels she had chosen mathematics, chemistry, biology and French. Rose was very successful in her GCSEs gaining 8 A^* and 2 As. She felt that the main influence on her subject choices was her future career.

to do with what I want to go on and do in the future because I had to do three sciences of some description

Individual interview

Rose explained that one of her reasons for choosing subjects for a certain career was to do with future security.

> I think so because we have a lot of pressure put on us and quite a lot of people worry us about what you are going to do in the future, and I think it is, it's just something that is always niggling, you want, you don't want to study a course when you don't know what is going to happen afterwards

Individual interview

This focus on careers was one of the reasons that Rose felt people, and girls in particular, did not choose to continue to study physics.

> I think one of the main reasons that people aren't choosing physics, I think a lot of people who have got career focuses it is the obvious careers, for example medicine or law or business, that seems to be the people who I know have got clear focuses on what they want to do, they all seem those kind of focuses, whereas people who don't have focuses they don't, they, yeah they could be more interested in just looking at science generally, but I think that if you knew from physics that there were certain jobs that you could get I think that is the worry that people don't really want to study physics and go on to study physics 'cos they don't know that there is definitely a job for them out there, what kind of jobs they might get with a physics degree, but if they knew what kind of jobs they could get, look at the employability of people who have studied physics, I think that would definitely increase the amount of people who want to do it because a lot of people want to do medicine, law and things 'cos they know if they do get onto those courses then afterwards they have fairly guaranteed jobs, particularly medicine

Individual interview

Rose's A-level choices were closely linked to her future career aspirations. This was also demonstrated by students in Pike and Dunne's (2011) study who made it clear that their future subject choices were linked to careers. This was also an aspect of Boe et al.'s (2011) work where they linked choices with the utility value of a subject.

At the start of the interview process Rose had not decided on a career, just something in science, so was considering chemistry and physics, her two best science subjects, alongside French and history. By the time of her final interview, Rose had decided that she wanted to study medicine. To do this she needed to take three science subjects and had chosen chemistry, biology and mathematics but not physics. She explained that she found chemistry and biology easier than physics because she felt they came more naturally to her. Talking to her it appeared that she felt that she would be able to gain top grades for these subjects at A-level and so be successful in gaining a place to study medicine; the influences of the discourse of achievement on the subjects she chose to study post-16. (Universities that offer medicine expect entrants to have gained A* or A grades for their A-levels). Rose gained A* grades at GCSE for mathematics, chemistry, biology and physics and she told me that the marks for physics were the second highest of all her GCSE marks. (The GCSE results sheets give marks as well as overall grades). From a grade achieved point of view alone, it could be suggested that taking A-level physics would have been a good idea. However, Rose felt that she had had to work hard to achieve this physics grade and that would not translate into a high A-level grade. Rose here is 'buying into' the commonly held belief that physics is hard (Francis, 2000). Therefore not only is A-level choice based on future career aspirations, it is also based on the path that Rose feels will most easily allow her to achieve that goal.

Rose's relationship with physics was very much linked to her relationship with her physics teacher and how he taught physics. In the first group interview I asked the girls what influenced them to choose certain subjects for A-level. One of the other group members said that she felt that teachers were a big influence on her choices. She said that she liked physics as a subject but that her teacher, who she felt was not very inspiring, had turned her off physics. Rose then explained how her teacher had also influenced her relationship with physics.

> this year I've got like a really good teacher and he's got me, he's the one who's got me really interested in physics. Last year I kind of didn't like physics at all but this year he's got really interesting lessons, really interesting and things like that and he kind of explains more, such as this will happen because of this whereas I didn't find like last year that I had that explained to me very well. He makes it really interesting, makes the lessons like really fun to be in so I really like physics this year
>
> Group interview one

Even though Rose had expressed an interest in taking physics A-level in her questionnaire she was now not so sure that she would because of how her physics teachers had influenced her relationship with physics.

> in fact I wouldn't want to do physics. I would love it if we had the teacher I've got at the moment but if I didn't, if I didn't care what teacher I was going to get, I know if I was going to get some teachers, another teacher like perhaps I wouldn't be as interested in physics. I think I was 'cos I did struggle with physics last year the only reason I get it this year, like really been listening and working really hard at physics. I really find the motivation to do that quite hard if I had a teacher who didn't explain it properly for me personally
>
> Group interview one

In the second group interview, Rose still had very positive things to say about her physics teacher.

> I find physics really difficult as a subject but with my teacher, my teacher is helping my class. They are all, we all work together and help each other in class and we are encouraged to do that so it is so much easy for physics. I think we just do that
>
> Group interview two

Rose comments positively about how the teacher works in a collaborative manner with his students. Schunk and Meece (2005) found that self efficacy increased in classrooms where teaching was in a more collaborative manner, where there was emphasis on the importance of effort and where there was meaningful learning linked to student interests. This is very important for girls, who often display a lower self efficacy than boys in science (Britner and Pajares, 2006). This is certainly the case for Rose.

Rose went on to describe further aspects of her physics teacher, in particular how he interacted with the students on a personal level, that had helped her to engage with the subject more than previous ones had.

> my teacher is kind of a bit different from theirs, like he is really relaxed about physics, but he, he does it, he teaches it really well and he is a really nice kind of teacher as well, so he is also, he is really good about being nice to people in the class and he will, he is quite understanding like about people
>
> Group interview two

> the way he teaches is really engaging 'cos he is really so passionate about his subject and he is really good about helping each of us individually
>
> Group interview two

> he is really good about giving you extra time or something; he will be really good about sitting with you and giving you extra help so that you understand, he is really good
>
> Group interview two

In her individual interview, which was after she had received her GCSE results, I asked Rose how much she felt her teacher had contributed to her GCSE Physics success. She felt that he had.

> he knew that I was worried about my final module 'cos I wanted a good grade on my last module, 'cos I had to get a good mark in order to get my A star overall and I think he understood that and he was willing to put the extra time in after school and during lunch times and things. I think that worked towards me getting my A star..........he knew that what I really wanted was an A star and he was willing to put the extra time in for me to get my A star
>
> Individual interview

In the final individual interview I asked Rose if her decision not to study physics, even though she got her second best GCSE mark for physics, was related to the teacher of not. She felt that it was.

> I don't really regret taking any of my subjects particularly, I think it is a bit of a 'what if' but then, it is the same with the physics, if I had gone and taken physics at A-level and then not got on with my physics teacher then I am sure it would really be the same and so it's hard to kind of say whether or not I would have preferred to do a different subject and I think it is just dependent on the teachers
>
> Individual interview

Rose's identification with physics was, in part, dependent on how enjoyable the teacher made the subject or not. Rose recognised that a previous teacher had not helped her to enjoy physics and so she did not have a strong identification with it. This second teacher had got her interested in physics because she felt that he made the physics lessons interesting, fun and relevant; as reported by Osborne and Collins (2001). She also described how the physics teacher cared about his pupils and how he would go out of his way to help them to achieve what they wanted. He had helped Rose by offering her extra tuition in lunch time and after school. Rose's relationships with her two different physics teachers demonstrates how important a factor a teacher can be on whether pupils will develop a strong identification with physics and be willing to embrace the figured world of physics or not. The relationship between students' attitudes to science and their interpersonal relationships with their teachers was reported on by Wubbels and

Brekelmans (1997) who found that when teachers acted in an understanding way to their students, classes were more effective overall. The model used by Wubbels and Brekelmans (1997) was also used by Fisher and Rickards (1998). They found that students had a better relationship with mathematics when their teachers demonstrated helpful and friendly behaviour. They felt that these interpersonal behaviours between the teacher and the students could be as important as teaching methods and styles in describing an effective mathematics teacher.

The importance of these interpersonal behaviours is clearly demonstrated here in Rose's relationships with her teachers and the subject. The first teacher did not encourage Rose to see physics as an interesting subject that she would be happy to engage with further. The second teacher changed Rose's opinion completely and made her think that physics was a figured world that she would like to engage with. However, this engagement was teacher dependent; an issue with students progressing to further study. As Rose described, one of the reasons she had not chosen physics for A-level was because she may not like the teacher who taught her. Rose's entry into the figured world of physics and her continued habitation there was dependent on the teacher. A poor teacher would have meant that Rose did not feel she could stay in that figured world so rather than risk this she left the figured world after GCSE.

In her questionnaire Rose said that she felt she was about the same ability in physics as the rest of her class and liked physics more than her friends. (These were the questions used to give a simple measure of the level of self efficacy reported by the students.) In the third group interviews I asked the girls again about how they would grade their ability in physics relative to their class with one being the top grade. Rose graded herself at a two.

> two 'cos I'm not top..... some of my class are definitely like one, they know everything there is to know about physics
>
> Group interview three

When I asked Rose the same question in the individual interview which was after she had received her GCSE results (she got a A* for GCSE Physics) she admitted that she would just about score herself as a one but was still not completely sure of this.

> I guess but I don't know if it was that I'm good at physics or just 'cos I worked really hard and learnt everything so much
>
> Individual interview

Rose's reluctance to give herself a grade one demonstrates how difficult it is to measure self efficacy and how problematic measuring just self efficacy alone is to using it as a predictor of further study (Britner and Pajares, 2006). Using Bandura's (1982) four causal factors that affect levels of self efficacy (mastery, vicarious, social and physiological) and the proposal by Britner and Pajares (2006) that of these four factors the mastery factor has the greatest influence on self efficacy, we would predict that Rose, who gained a top grade for GCSE physics, would have a high self efficacy. However, Rose is not confident to give herself this high level of self efficacy.

She explained why she was still not sure about giving herself a grade one by saying:

> I think that with everything you have there are things that you just find easier 'cos I think I find chemistry and biology easier than I found physics, just because I think that there are certain, there are just certain things that come more naturally to you and I think that I find that biology and chemistry come more naturally to me than physics, but obviously I do think it was the hard work 'cos I put lots of hours of my time into learning physics
>
> Individual interview

Even though she expressed the belief that some subjects are naturally easier than others she was convinced of the argument that hard work could overcome that barrier.

> if you work hard you can, well especially I think, maybe specific at GCSE level, but I think that if you work hard at GCSE level then everybody could get an A star at GCSE if you put the effort in
>
> Individual interview

Rose's relationship with physics is an interesting one. Her GCSE grade of A^* demonstrates that she can achieve but she is not confident to say that she is good at physics or has a high physics self efficacy, and puts her top grade down to hard work. Rose's belief in hard work meant that she did manage to achieve the highest grade possible at GCSE. However, she was not sure that she would be able to achieve the grades needed to achieve well at A-level because it had been so much hard work to get to the GCSE grade, an example of how many factors (mastery of the subject, perceptions of hardness, the discourse of achievement) can contribute to how we perceive our capability of learning at a designated level, our self efficacy and ultimately our subject identity.

Rose is developing an identity that has a focus on achieving her goals and those goals are focused on her future career and security. She has moved towards a definite career aim, medicine, from a starting point of 'just a job in science'. She feels that she knows where she is going and that others see her as a person who is focused on that aim. She has chosen subjects for A-level that she feels are the best ones to allow her to achieve that aim.

Her identification with physics was very dependent on her teachers. One of her teachers encouraged her to embrace the figured world of physics. Her achievement of an A^* for GCSE physics could lead to her seeing herself as a physics person and part of the figured world of physics, but her description of how she achieved that grade, by hard work only, means that she does not do this.

Indiana

Indiana was in year 10 at the start of the interview process. I met her three times over the coming four terms[32]. Indiana described herself as White. Her mother had been a teacher but had had to leave due to illness and now worked in a clerical job. Her father was unemployed when she completed her questionnaire; he had previously had a well paid job but Indiana did not say what this was. Her older brother, who was 25 at the start of the interviews, still lived at home because he could not find a job after leaving university whereas her older sister had a job that 'had a reasonable salary for her age'.

On her questionnaire Indiana said she was not thinking of choosing physics because 'I don't find it particularly interesting and I don't want to have a job involving physics'. However, the other subjects she was thinking of choosing for A-level were product design, mathematics, chemistry and history. She wanted to study product design and mathematics because she wanted to have a job involving them whereas history was because of interest and chemistry because it looked good. I was interested to find out why she had rejected physics because if she was so interested in a career that involved product design and mathematics I could not see how she could avoid elements of physics in this future career.

This interest in product design was very evident throughout our discussions. This was the one subject that she was consistent in saying she was going to study for A-level and was interested in pursuing a career in this area. She acknowledged that many people thought she was odd for having an interest in the subject, especially as many saw it as a boy's subject. Indiana acknowledged that there were many more boys in her class than girls, but she did not mind this; she enjoyed the subject and was going to carry on studying it. The figured world of product design, as described here by Indiana, has many similarities with that of physics. Both are perceived as being dominated by males. Both are places where society's image of that world is one where girls should not play a part. However, Indiana feels that she can be a part of the product design world because she

[32] It is Indiana who I did not interview on a one to one basis.

enjoys the subject – a parallel for those girls who are interested in physics and feel that they can be a part of that world. I could also speculate that, since Indiana is happy to be part of one world where she is having to overcome barriers to her participation (Aikenhead, 1996), she would also be willing to participate in another, that of physics, if she wanted to.

Indiana's participation in the figured world of physics was not suggested by the rest of her questionnaire responses. The rest of her questionnaire responses were consistent with a dislike of physics. Her physics words were 'bored' and 'difficult'. She did not agree with any of the statements about physics lessons. She was neutral about her ability in physics and her liking of the subject when compared to others, and finally she did not describe herself as a physics type of person because it did not interest her.

In the first of the group interviews Indiana confirmed her dislike of physics. She felt that she was good at mathematics (in fact she had already passed her GCSE obtaining an A^* grade and was now studying additional mathematics) but that this did not relate to her being good at physics, even though her father thought it should.

> Mine's more to do with me being good at mathematics. My dad kind of expects me to be good at physics and I don't really believe that, it is just a bit of an effort and then it kind of bores me as well, causes me trauma.
>
> Group interview one

Indiana's relationship with physics and how that was influenced by her teacher came out in the second group interview when I asked the group to tell me about their physics teachers. In the first interview Indiana had been an active contributor, willing to discuss her reasons for not liking physics and discussing who had influenced her future subject choices. Now, asking about her physics teacher, she talked with real passion about how she felt about him

Indiana	I don't like him
Deborah	I'm going to ask why a lot now[33]
Indiana	well what was I going to say, um, I really like product design so I was going to do product design, further mathematics and physics for A-level 'cos I want to go into engineering. I don't really like physics but it helps you get into engineering. Otherwise, but like when I said to my teacher would I be alright doing physics A-level, I'm on a A, and he just said no, have you ever wondered why you are in set 3, you are going to get a D if you do it for A-level, so it was like no confidence in me.

Group interview two

Looking at the words on paper does not bring across how Indiana felt at this time. Her tone of voice and her body language clearly indicated how much she had been affected by this incident. It was obvious that she felt let down by her teacher, was incensed that he felt that she was not capable of achieving a good grade at A-level even though she was predicted a grade A for GCSE and was confused as to how he came to this conclusion.

At this stage of the interview I wanted to find out more about this physics teacher. For several minutes, the interview became focused on this physics teacher with Indiana leading the discussion. Ruby, also a member of this group, was taught by the same physics teacher but in a different group. She agreed with many of the comments Indiana made about her relationship with the teacher since they reflected her own. The third member of this group, Skye, who had a different teacher, showed by her body language that she was interested in this conversation and felt that it was important for Indiana to talk about her relationship with physics and her teacher in this safe space.

Deborah	so you are predicted to get a grade A
Indiana	I'm predicted to get an A star but I'm on a A

[33] The asking of the 'why' question was seen as my role in the interviews and the girls joked about this.

Deborah	right for physics
Indiana	yeah
Deborah	so what was his reason? It's not going to go any further than this
Indiana	that everyone that gets an A ends up getting a D for A-level which I didn't really understand 'cos surely.......I don't think he wants any of our class to do it 'cos he like.......I don't know anyone who does like him
Deborah	can I ask a very leading question[34]
Indiana	yeah
Deborah	'cos obviously the whole topic is about girls and physics, does he, are his favourites boys or has he got any girls he likes
Indiana	oh he doesn't like any of the boys in our class......I don't know, he doesn't really have favourites, he just doesn't tend to like our class
Deborah	I was wondering whether him, you know, if he just discouraged everybody or it was just girls
Indiana	yeah, the highest person in our class also said that she wanted to do physics and he said don't do it to her although she is on A stars in all her sciences......he just seems to think because we are in set three we will be incapable of doing A-level but then he is like, it is very mathematics based so I don't think you can handle it, but I've done my mathematics GCSE because......I am doing further mathematics and stuff so it's not really

Group interview two

Indiana obviously felt that this teacher was not supporting her in her possible future subject choices, but was also not supportive of other members of her group. She felt that he had little respect for her ability, in physics or mathematics,

[34] Flagging up that this was a leading question was, on reflection, not good research practice but I felt at the time that this was OK based on the fact that all the girls knew the subject area of my research.

and that he also showed little respect for any members of her group. Teacher and student interpersonal relationships are very important in the classroom (Osborne and Collins, 2001; Wubbels ad Brekelmans, 1997). Even though I asked specifically if she felt this was due to gender issue directly, Indiana described how the teacher did not encourage any members of her group to think about continuing to study physics. The teacher demonstrated that he did not think that any members of this particular class were capable of achieving a good grade in A-level physics. Even though members of this group, including Indiana, were predicted high grades at GCSE, because they were setted into a lower ability group, the teacher did not feel they would, as a whole, have the ability to be successful in physics. This could be hiding a gender issue as most schools have more girls than boys in their lower ability sets for mathematics and science. However, this would need further investigation and any direct gender issue for this teacher cannot be concluded from this short discussion.

That this teacher did not feel that any of this class was capable of continuing to study physics was also reflected in a further discussion when Indiana felt that he (the teacher) had denied her and the rest of her class access to an outside talk about physics because of their perceived ability.

> And there was like a physics talk which literally the whole year went to, but our class because he didn't, he said that our class would not be good enough to do it for A-level
>
> Group interview two

At the third group interview, carried out about four months after the second interview, Indiana was still talking about how she felt her physics teacher had actively discouraged her from taking physics A-level.

> All of our year went to a physics talk at one point during the lesson and we didn't, we weren't allowed to go our class 'cos we weren't going to be clever enough to cope with A-level, so it was just like I turned up to mathematics, 'cos I am fast track mathematics, and I was like the only

> one there ‘cos I am the only one in my science group, so I was in mathematics alone for a whole hour
>
> Group interview three

To still have such a raw feeling about this, a considerable amount of time after the incident, shows just how much Indiana had been affected by her teacher's attitude.

Her relationship to physics was very influenced by the teacher. She graded her ability (a measure of her physics self efficacy) as a three or a four (out of ten with one being the highest grade) based on her results, but when asked to compare herself to others

> in our class, we are expected to be done down by the teacher, so worse
>
> Group interview three

Self efficacy can be affected by four causal factors (Bandura, 1982). These include mastery experience related to previous performance of tasks and social persuasion or exposure to judgements about previous experience, generally given in education as feedback. A higher self efficacy is related to having good mastery of the task given and positive feedback. Each of these causal factors will influence self efficacy levels to a different extent and individuals will be affected by them differently. Indiana demonstrated a good mastery of physics, as evidenced by her results, so would be predicted to report a high self efficacy, but this level was reduced by the feedback she received from her teacher, not just about her results but about her physics experience in general.

Later in the interview when we were talking about whether the girls felt that physics was a male subject Indiana again talked about how her teacher discouraged people from choosing physics A-level.

> our teacher said to a girl in our class that she shouldn't do it ‘cos she is getting good grades, but that she shouldn't do it at school ‘cos, and that

> was like makes sense out of it so.........she really wanted to do it and then he was like oh no, that is a boys' subject and ......
>
> Group interview three

Earlier in Indiana's narrative I described how her teacher did not encourage any of her group to think about continuing to study physics because he felt that they all did not have the ability necessary for this. This comment above, which is very surprising to hear in a 21st century classroom, moves this discussion from one of general ability of the class to identifying physics as a boys subject. Whether this is what was actually said or is just Indiana's interpretation in light of the fact that I am asking her about 'girls and physics' is difficult to decide. One hopes that it is the latter not the former.

At the start of the research process, Indiana describes her relationship with physics in negative terms. She does not enjoy the subject, she does not find it interesting, she finds it to be boring and difficult and is definitely not thinking of continuing her study of it past GCSE. She does however have a very big interest in product design and mathematics and these are subjects she wants to carry on in the future and have a career involving them. At some point (possibly following a careers interview or a discussion about her A-level choices, but this is not made clear), she realises that to support her future career in product design, studying physics at A-level will be very helpful. At this stage she goes to talk to her physics teacher, the person she sees as being a member of the figured world of physics, a person who can help her to move into this world.

This teacher shuts the door on her possible entry into the figured world of physics. He tells her that she should not enter this world, that she would not be successful in that world and that the world of physics is not for her. His reasons for this do not make sense to Indiana. He tells her that she will not be successful at gaining a good grade for A-level because she is in set 3; she would only possibly gain a D grade. (The school split their students into two populations, an upper and a lower, based on attainment and even though Indiana is in set 3 she is in the top population so is taking GCSEs in the three separate sciences). Indiana is confused by this statement as she is predicated to gain a grade A for GCSE physics (which she did in fact do). Another reason the teacher gives is that she would not be able to cope with the mathematics side of the physics syllabus. Again, Indiana is confused by this as she has already achieved a grade A^* in her GCSE mathematics, a year early.

It is not obvious to her why this teacher feels that students who gain a grade A for GCSE physics will only go on to gain a D grade at A-level. This reasoning is very confusing for Indiana. Gaining a grade A for GCSE indicates a high level of attainment and most pupils would expect that this indicates that they have a good understanding of the subject and that if they choose to study that subject further then they will be successful. Not only is this teacher saying that this will not happen for physics, the statement is causing Indiana to doubt whether she will be successful in any subject where she gains this grade at GCSE. This is not only making her identification with physics more difficult but is having an influence on her overall identity development as a high attaining student.

The teacher also made a statement (by implication through his actions) to the whole of Indiana's class about their lack of ability by not allowing them to attend a talk aimed at pupils who could go on to study physics at A-level. This again demonstrates that the teacher has a major influence on whether any of his pupils could embrace the figured world of school physics.

Charlotte

Charlotte was part of the Hinton School year 10 *Yes* mixed group. She was thinking of choosing A-level physics because 'I am good at physics and understand it as I am also good at mathematics but it is not necessarily my favourite subject'. Charlotte was one of the few girls who rated herself as one of the best at physics when compared to the rest of her class although she felt she only liked physics as much as her friends. This could be because she described a physics type of person as someone who was 'quite geeky' and she was not sure if she fell into this category or not, even though she was good at physics. In the end, Charlotte gained a grade A for GCSE Physics which she said was due to her lack of effort because she felt that if she had done more work she would have gained the top grade.

Charlotte came from what could be described as an upper middle class or professional background. She categorised her father as professional and her mother as clerical on the questionnaire. During the course of the interviews she mentioned a brother who wanted to go into engineering. She felt that her parents would support her to do what she wanted. She talked about them wanting her to go to university but that she could choose what subject she wanted to do.

Charlotte's other original choices for A-level were French and Spanish because she was good at languages, mathematics because she understood it and geography because she found it interesting. In the end she chose mathematics, geology, French and Spanish. She did not choose physics 'not because I don't like physics, that's just because I preferred other subjects[35]'.

Charlotte explained that the subjects she finally choose for A-level were

> what I am interested in the most, I have absolutely no idea what I want to do later on, like clueless and it was basically, it was subjects that I did, partly I did the best at, the ones I enjoy the most and I was most interested in so
>
> Individual interview

She explained that she did not feel pressurised into choosing particular subjects; she just chose the ones that were her favourites. She talked about her choices by saying

> I know a lot of people have said that, that's like, that's a random choice and that is very me, I am very random, so yeah I know in that respect it

[35] Geology is only offered by a few schools for A-level.

> probably reflects myself, but I know, yeah I am, I will go with what I am confident with and if I am yeah, I am good at this subject I will take it, see how it goes
>
> Individual interview

Previous research into choices (Eccles et al., 1983; Boe et al., 2011; Pike and Dunne, 2011) has shown how many post-16 choices are based on future career goals. It is refreshing to see that not all girls make their post-16 choices with this focus in mind.

In an earlier group interview Charlotte described herself as

> I guess strong, like physically and mentally and I try, yeah positive as well, definitely positive sometimes
>
> Group interview three

When talking about her subject choices she described how other people might perceive her choices.

> if they think, oh that is a bit weird, why would you do that subject, I am just like oh, like a lot of people have said why are you doing geology, it's rocks, but I am a climber, I like rocks, rocks is my thing, rocks isn't your thing, deal with it, who cares
>
> Individual interview

Charlotte went on to say

> I don't see why we should conform to society's stereotypical stuff, I don't think, I, who cares if you are a guy or a girl just 'cos you do, like some people think physics is manly or for men or whatever or is not very girly, who cares, if you like physics go with physics, it doesn't make a difference
>
> Individual interview

Charlotte described herself as liking to break stereotypes and described how as a rock climber she was the only girl of her standard in her county and so was used to being the odd one out. Charlotte spoke a lot about climbing, it was her main hobby. She clearly related her strong physical and mental attitude to her ability in climbing and her one-mindedness in pursuing a hobby which not many other girls participated in. She often used the phrase 'man up' when talking about how she felt other girls were not confident to stand out from the crowd and she felt that this came from her climbing experiences. These references to climbing and the fact that Charlotte used climbing terms to explain how she felt about how others saw her demonstrate aspects of both hetereoglossia (Francis,2010) and female masculinity (Mendick. 2003 and 2006). To be a climber Charlotte has to perform many aspects of, what others might term, masculinity; she has to be strong, active and objective in order to be the excellent climber that she is. This does not make her, to my mind, 'more masculine' than other girls, it just demonstrates that a binary ordering of feminine and masculine traits does not reflect what is actually happening in identity work. Charlotte is happy to perform masculinity and it does not make her any less feminine, from her point of view. She also feels that other girls should have the confidence to perform masculinity, hence the use of the term 'man up'.

She then described how she felt other people might not be as confident as her to pursue subjects that they felt others would ridicule them about.

> I think a lot of people would think, would worry about what people thought of them, should say if I took physics, if yes another girl took physics and then people said why are you taking physics you should be taking like history or something like this, which people maybe possibly see as a bit more, not girly, but a bit more, it is just not as sort of stereotypical male orientated subject you know, and then yeah some people, just they go, oh no I am not really sure some people are saying I should not do physics, I am a girl, whatever, but and I know that would affect some people's choices, I know it definitely does, some people would not take a subject because they think, because of what they think

other people would think of them and I don't think that is really right and that you should just do what you want

Individual interveiw

Charlotte was however confident that things would change in the future and that more people would choose subjects that they wanted to and would not be so affected by what others thought. She used girls and physics as an example of this.

I think it will change, I think everything changes all the time, so I think it has to change at some point, but whether that is in the next 10 years or the next 100 years or whatever, but I guess, 'cos a lot of scientists seem to be men, the sort of founding, like fundamentals of like physics, a lot of brainy people like Einstein and Newton, they are all men, so I guess our foundation of physics would be if discovered by men it should be continued by men, but that is not true, there are female astronauts........it is just time to change, people change and they go actually, maybe this is more normal or what they perceive as normal, it is changed so much

Individual interveiw

During the course of our meetings, Charlotte always struck me as someone who was very comfortable with her own individual identity. She was not afraid to say what she thought and not afraid to talk about her, what she termed, unusual hobby of rock climbing. She also knew that she was very good at climbing, at a standard above all the other girls in her county, and that this also made her stand out even in the rock climbing world.

When discussing how she would describe herself, Charlotte demonstrated that she felt that she knew who she was and how other people saw her. She described herself as not being affected by what other people thought of her. However, she did recognise that other people were so affected and that this could make identification work difficult, especially if how you saw yourself was different from how you felt other people saw you. This conflict could result in an identity more geared towards others than being true to your own 'inner self'. Charlotte did not feel that she had this conflict and that her identity as seen by others was the same as how she saw herself.

In Rose's story, we saw how the draw of a future career had shaped her subject choices and also her identification with physics. For Charlotte, there is no future career in the picture. She explains that she has chosen her A-level subjects purely on interest and enjoyment. She has no idea about what she wants to do in the future. This is a bold statement. Charlotte feels comfortable with the idea that at the moment her choice of subjects to study does not need to be linked to a future career. She realises that this will come in the future, but for now she is sure enough of her own identity to not feel that she has to do what others think she should do, but that she can do what she wants to do.

Scout

When I first met Scout she was in year 9 at Hinton School. She was very noticeable in the group; she was the one with the 'sticky up' hair that had a coloured streak in it. The colour of the streak changed over time and the length of the hair did but it remained 'sticky up'. On her questionnaire Scout indicated that she did not live in the town where Hinton School is situated but in another small town about ten miles away. This would mean that she had a longish bus journey every day and that Hinton School was not the nearest to where she lived. Studying at Hinton School had therefore been a choice rather than just going to the local school.

On her questionnaire Scout reported that her mother was from a professional background and that she did not know what her father did. During the interviews it became apparent that she lived in a single parent household. She did not mention other family and when she spoke about home it was just about her and her 'mum'. She explained that her mother was a supply teacher and that it was sometimes difficult because she did not have a full time job. She felt that her mother wanted her to be successful at school so that she could get a good, secure job in the future.

I chose Scout as part of the year 9 *No* to physics but *Yes* to other sciences group as she indicated on her questionnaire that she was thinking of taking biology, French, mathematics and art for her A-levels. The decision not to choose physics is often linked to its closeness to mathematics but here was a pupil who was interested in studying mathematics so this could not be the barrier for her to the study of physics.

On her questionnaire Scout said that she was not going to choose physics because she found it hard. Her choice of words to describe physics in a later part of the questionnaire was mixed. They were – 'like', 'anxious', 'difficult', 'interesting' and 'confusing'. My feeling is that Scout was not sure where to position herself with regards to physics. Some of it she liked and found interesting. Other parts of it confused her and made her anxious. She also thought physics was difficult.

One theme that emerged in the first group interview and that Scout then mentioned in all the subsequent interviews was that she did not feel confident about her ability in physics. One of the reasons she gave for this was the lack of feedback that she received from her teachers.

> with marking, it's like you don't really know what you are trying to show when you are doing specific work.....you don't really know what you are actually trying to show, like skills in physics
>
> Group interview one

She linked this lack of knowing what she was trying to demonstrate in her work in physics to the lack of reassurance from her teachers that she was doing the right thing.

> I don't really, it's not that you are wrong or you don't know what to do, it's just that I want reassurance that I am doing it right.........then if you

> don't think you are [doing it right] or you think you might have a different sort of thing, then they (teachers) can just come over and check to make sure that you are doing it right, cos otherwise you are going to feel then, if you haven't had that reassurance
>
> Group interview two

In the follow up one to one interview I asked Scout again about the relationship between the feedback she received and her relationship with subjects. She again agreed that this was an important issue for her.

> I kind of need to know what I have done right and what I have done wrong in order to feel that I have done well and that I can improve, 'cos if I am not getting told what I can improve on then I don't really get which bit I have done right
>
> Individual interview

For Scout, when she receives effective feedback this supports her future performance and allows her self efficacy to increase. It is when she does not get this type of feedback that her self efficacy decreases.
The second group interviews focused on teachers and teaching of both physics and the interviewees' favourite subject. Scout linked her liking of history to the help she received from the teacher.

> if you need help with different types of exam questions, then she shows us how to get them on the school website......you get lots of help
>
> Group interview two

Scout contrasted this to her physics classroom where she did not feel that she could ask for help.

> it puts people off 'cos they, oh I can't put my hand up and say I don't get it, 'cos they always snap at you, don't get any help
>
> Group interview two

As stated above the interpersonal relationship between teachers and their students has been previously identified by Fisher and Rickards (1998) as being very important in how students engage with a subject. Scout is more confident in her relationship with the subject and likes it more when she sees the teacher as being helpful and approachable. With physics, where she considers the teacher to be unapproachable, as demonstrated by the statement that the teacher 'snaps' when questions are asked, Scout links this inapproachability with a dislike of the subject.

In the third group interview she again spoke about her lack of confidence and this time discussed it when asked where she would go for help if she had a problem in physics. I asked her if she would ask her teacher for help.

> Maybe, it is just 'cos it is top set, you don't really want to ask the teacher what it is, 'cos it feels like everyone else knows what it is, so I would rather just ask more people on my table rather than ask the teacher
>
> Group interview three

This was expanded on in the individual interview.

> there are a lot of bright people in the top set, are really sure....they know everything and then if you don't get something, a lot of well, quite a few people, will be like, why don't you get it 'cos it's really easy....so kind of if you don't get it then you kind of don't want to tell anyone else that you don't get it.....it kind of makes you feel you are like not as smart as everyone else......kind of makes you a little lower on the ability scale
>
> Individual interview

For Scout, the top set is a place of competition not collaboration. This place of competition does not allow self efficacy to increase (Schunk and Meece, 2005). The top set is made up of people who perform 'being smart'. Scout feels that if you do not perform 'being smart' you are marked out as being different to the other members of the group. However, Scout did describe herself as 'being smart' in other parts of the interviews. This appears to me to be another example of Scout not really knowing how to perform 'being herself', not the self that she thinks others want to see or hear about.

Scout also does not think she can compare herself to her peers in her class, so does not gain in self efficacy from seeing similar others being successful; the opposite in fact. This perceived lowering of her physics self efficacy, which forms part of her physics identity, leads to Scout having mixed feeling about her place in the figured worlds of physics and science.

As mentioned above Scout's list of physics words in the questionnaire showed a mixture of attitudes to the subject. They were – 'like', 'anxious', 'difficult', 'interesting' and 'confusing'. Scout talked about her place in mathematics and sciences in the third group interview.

Scout	I have always felt kind of like odd though, 'cos like mathematics and science, I don't, that is kind of like why, I have think that boys are seen as better at it 'cos I have always felt kind of odd kind of being the girl who is good at mathematics and science and things, and I kind of don't have any, well kind of, I am the smartest person in my family and I don't have any like close, or my dad or anything, so it is kind of like, just kind of odd being a really smart girl with lots of smart boys
Deborah	and that doesn't make you feel good
Scout	well, I don't mind, it is, is just that kind of why I see boys as being more academic 'cos I have always felt weird, well being a really smart girl in with boys
Deborah	do you feel weird 'cos, that is, do you think other people
Scout	I just think other people would think it is weird and like the groups that I am in is a load of smart boys and it has always been, and they are like afraid of you, really smart girls, and I don't think that makes sense or not, that is just kind of how I feel
Deborah	so you would like to merge into the background more or

Scout	well I don't mind it, I, just, that is why I see it as that, 'cos if you are really smart than, but 'cos that person who is in your year who is really smart you just know they are and, like, you are always expect it to be a boy, 'cos you are like a really smart boy who does everything and then, but in some of the years in like school, it was just a small one, and it was like everybody get like, if you are a girl, I don't mind, I like being smart but I think that is just why I see it as boys are better
Deborah	so the need to change everybody else to it is all to do with how everybody else sees you and if everybody else changed
Scout	yeah
Deborah	would you feel better about then
Scout	I do think it would make girls like, more to try harder at getting good science and stuff, because it is not as weird

Group interview three

In this exchange, Scout describes herself as weird and odd for being, what she described as, smart and for liking the academic subjects of mathematics and science. She feels this because she usually finds herself studying these subjects within male dominated groups, groups she feels she should not be part of. Scout describes how she feels that most people expect the smartest students in a year to be boys not girls. As a girl, who is often at the top of her year group attainment wise, she feels that she is 'the odd one'. However, she also says that she likes 'being smart' even if it is also weird. Perhaps, as Scout says, it is not really her who is the odd one out, but it is society's perception of who is good at science that is wrong.

When I interviewed Scout on her own, about a term after this last group interview, I asked her to read the above section and asked her how she now felt about being good at science and mathematics. Her response was:

> I think I'm, I think I kind of it actually makes you feel really good if you are a girl and you are really good at science and mathematics 'cos you don't see anybody, I don't know, a lot of, a lot of the other people in the top set are boys and a lot of the boys go on about how smart they are and a lot of the girls don't, so I think to be, to find you are good at science and stuff it feels really good, but I think a lot of people do think that it is just boys who are good at science and mathematics and things
>
> Individual interview

When she is talking about how she sees herself in relationship to science and mathematics this is linked closely to how other she feels other people see her.

> I think that I seem sort of weird and different in the way other people might see me because I am not, I am not that good at music and stuff that's not academic, and then a lot of people say there are a lot more girls who are doing less academic stuff or less sciency stuff and that doing sciency stuff is what boys do, 'cos there are so many boys in our lessons as in, even the girls that are in the lessons, in like the top set, a lot of people think that they are not as smart as the boys, but they are just in there 'cos they are like the smartest girls, I don't know what else to say
>
> Individual interview

> it is just that a lot of boys who are winding you up, being a girl being really, really smart is that you are like a boy and that is really weird
>
> Individual interview

> I kind of, yeah, I had a bit when you feel like, like why do I, I kind of stand out anyway, so like on top of that, with the like being good at science and everything, I just kind of, yeah, but definitely, a lot of the smarter boys see you and what are you doing
>
> Individual interview

Scout appears to be performing 'weirdness' or to make herself stand out from the crowd with her looks as a way of offsetting how people see her because of her liking of science and mathematics. It is a case of 'Oh she looks weird so it doesn't matter that she likes boys' subjects'.

I asked Scout if she had any mechanisms for coping with how she felt other people, especially the boys in her class, saw her. She had two responses, one linked to how being smart made her feel and one linked to the good feeling that she got when she was able to help others.

> I know I am smarter than them, yeah, it is just like when you get something right and they don't, it just gives you inner happiness
>
> Individual interview

> I can help other people so I know I feel good about it, whereas they, they are not good at helping anyone else, 'cos they are like, they don't get why you don't get it and when they explain it, it is really confusing still
>
> Individual interview

It is interesting that earlier Scout talked about how not performing 'being smart' marked you out in the top set where it was expected that all the students were smart. Here she talks about how she likes 'being smart' and how good it makes her feel when she can outshine other people. Helping others could be seen as a feminine trait; demonstrating a caring attitude. This could be seen by others as an aspect of 'being smart' that is acceptable for girls. However, performing 'being smart' in front of others, especially boys, can be something that can be seen as demonstrating a masculine trait and boys may feel threatened by a smart girl. Scout, in her own mind, knows that she is smart, but does not want to perform it too often otherwise she performs an identity that others do not think should be part of a girls' identity.

Identity is the process of coming to think we know who we are, who others think we are and for others to think they know who we are. We come to recognise ourselves as certain types of people and others come to see us as those types of people as well. We do identification work throughout our lives, refining who we think we are as we encounter different situations. This identity work is done within figured worlds and we continue to encounter different figured worlds throughout our lives and come to embrace or reject them as we come to understand ourselves. Scout's story is one of identification work very much in progress. Scout performs weirdness and smartness within an outsider identity. She does not come from the same town as most of the students at this school; so that marks her as an outsider geographically. She performs weirdness through her appearance; another aspect of her outsider identity. She believes that she is smart; something else that she believes marks her out as an outsider. However, she does not always perform smartness as she feels this marks her out as a threat especially to boys in her set.

One of the figured worlds where this identification work is taking place is that of science (science overall at this stage rather than the individual figured worlds of each science). Scout is trying to find whether she has a place in this figured world or not. On the one hand she feels that she does because she likes science and feels that she is good at the subject. On the other hand her conceptions of the figured world are that it is predominately inhabited by men demonstrated by the fact that there are more boys in the top set where she studies science than there are girls. Scout is trying to find out whether as a woman she has place in the figured world of science.

Discussion

The narratives outlined above show us how four girls' identification with physics developed over one and a half years. Each of their overall relationships with physics is different. There are, however, influences (and influencers) and discourses that impact on their identifications that are similar.

In this discussion section I begin by describing the key features of each of the four narratives. I then move on to use the literature presented in Chapter 2 and

Three to discuss similarities and differences in the girls' identification with physics , concluding by using the notion of identity trajectory to describe each girls' developing identification with physics. I close by concluding how looking at physics identity as a whole, and by using narratives as examples, can give us insight into 'the problem' of girls and physics.

The four narratives

The first of the four narratives, that of Rose, describes a girl who becomes focused on her future career. Her A-level choices are made so that she will be able to gain entry into university so that she can pursue that career. She makes choices that she feels will enable her to gain the qualifications needed for entry into that career, to move into that figured world, with ease. However, move her away from that 'safe path' and you find that she has worries about her identity. She is conscious of the opinions other people hold about her; following a definite career path means that she knows what they think of her, but if she moves away from that, she is not so sure. She also describes how her teachers have influenced her identification with different subjects.

The second narrative, that of Indiana, looks at how a teacher can be seen as the gatekeeper for the figured world of physics. The narrative develops of a girl who is not sure about her place in the figured world of physics and is not sure whether she should embrace that world or not. She seeks guidance from her physics teacher, a person she perceives as a fully participating member of that world. How he interacts with her has a major effect on her identification with physics and her place in the figured world of physics.

The third narrative, Charlotte's, is about a girl who feels 'confident in her own skin'. She sees herself as being different but is not bothered about what other people think. She makes her choices based on what she in interested in. She is not driven by a future career or by conforming to what others think she should do. She is interested in physics, she feels she is part of the figured world of physics, but has ultimately decided not to choose it as one of her A-levels because there are other subjects she is more interested in.

The final narrative, Scout's, is one of contradiction and confusion. In some parts of the narrative, the girl feels happy to be part of the figured world of science and wants to embrace it further. However, she also feels that she should not pursue science because it is a masculine world. She feels that people see her as being different because she is good at science and mathematics; subjects that society thinks girls should not be good at. Scout appears to be an outsider; she at times embraces this outsider identity but at others wants to not stand out. These contradictions make it very difficult for her to develop an identity that she feels comfortable with.

Using narratives to describe influences on identity development

The literature discussed in Chapter 2 highlighted how the decision whether or not to choose to study physics post -16 was based on a combination of different factors and different influencers. I highlighted how choices are made linked to future careers, how these choices can be influenced by teachers and teaching, family and peers and by the stereotypical view that physics is dominated by White, middle class males. We find these themes echoed here in these narratives.

Choices influenced by future careers played a part in three of the girls' narratives. For Rose, future career was most important for her. As she focused in on medicine, she chose subjects that would help her to achieve this goal. Since she perceived chemistry and biology as 'easier' subjects, and physics as a harder subject, to allow her to gain the top marks needed to enter university, her identification with physics decreased. Here, not only was her choice of subject governed by her future career aspirations but it was linked to the commonly held belief that physics is hard.

Indiana's possible move towards physics was due to the fact that physics would be a useful subject to study alongside mathematics and product design; the utility value (Eccles et al., 1983) of physics was important here. Indiana was prepared to overlook her general dislike for physics if it would help her to achieve her career goal. Her interaction with her teacher, as described below, only reinforced her earlier feelings that physics was not for her and even though it had a high utility value, she rejected it.

Choosing subjects because they will allow fulfilment of a future career goal was, however, not the reason Charlotte gave for her eventual choice not to study physics. Charlotte made it very clear that she did not have a career in mind when she chose her A-level subjects. She chose those subjects that she was most interested in; those that she enjoyed and those that she had done best in. So even though Charlotte did not choose her subjects because of a future career, she did choose those that she had done well in and thought that she would be able to do well in again.

Chapter 3 focused on identity and self efficacy. The summaries of each of the girls' narratives given above briefly describe how, over the one and a half years of this project, they carried out identity work to come to think they knew who they were, think that others knew who they were and that they thought that others knew who they were all within the many figured worlds that they encountered on a day to day basis.

These four girls were all girls who conformed to teachers' expectations of what would make a good physics student; they were academic (Brickhouse, Lowery and Shultz, 2000), they came from White, middle class backgrounds (Brickhouse and Potter, 2001) and from families where science talk occurred outside of the classroom (Olitsky, 2006). However, three of them, by the end of the project, had already shown that they had not chosen to study physics for A-level and the fourth, Scout, was not thinking of doing so either when she did make her A-level choices.

The figured world of physics that all these girls encountered is within the physics classroom. The figured worlds within these classrooms are systems of social activity that are governed by the norms of that classroom (Varelas et al., 2011). These worlds are generated by both the teachers and the students but are found to often follow 'expected' lines. Shanahan and Nieswandt (2010) found that students, especially those who had encountered science classrooms before, had a clear view of what the expected role of a student was within that classroom. The figured world of the physics classroom is reproduced along these lines many times over. This can be called 'usual school physics' (following Boylan, 2010), where a traditional didactic approach is reproduced (Boaler and Greeno, 2002). Occasionally a different classroom world is produced, that where a more discussion based teaching model is used (Boaler and Greeno, 2002). Looking at the narratives, it can be seen that Rose participated in a different figured world of the physics classroom than did the other girls. Rose describes her physics class as:

> we all work together and help each other in class and we are encouraged to do that so it is so much easier for physics......... my teacher is kind of a bit different from theirs......... the way he teaches is really engaging

Rose's relationship with her teacher and his teaching methods was such that she did not feel confident to continue to learn physics if he was not teaching her. This was also fuelled by the fact that she had not had a similar relationship with her previous teacher, one who used more traditional methods in his teaching.

In stark contrast to Rose's relationship with her teacher is Indiana's. As described above, he told her that she would not be successful if she chose to study physics post 16. Brickhouse, Lowery and Schultz (2000) report that they found that girls who conform most closely to the teachers' view of what a scientist is are responded to most positively. Teachers are acting as a gatekeeper to the figured world of science or physics. The only people they think will be able to fully embrace this figured world are the people they think will fit into it most easily and be the same as all those who already inhabit that world. Indiana's teacher did not think that she would be successful as a physicist based on her predicted GCSE grade and how that would translate into A-level grades.

Whilst physics is being learnt at school, teachers are responsible for giving feedback to students about their progress and their understating of the subject. Feedback is one of the factors that has been identified (Bandura, 1982) as affecting the level of self efficacy. I have proposed that self efficacy is an integral part of identity (see Chapter 3, page48). Of the narratives described above, it was Scout's identification with physics that was most influenced by her self efficacy and that self efficacy was most affected by the amount and type of feedback she received from her teachers.

Wenger (1999) describes how identities are not static but are developed along a trajectory. Calabrese Barton et al. (2013) found that along those trajectories there are moments of shift when the direction of trajectory changes due to the person seeing themselves in a different way or perceiving that others view them in a different way. Overall, these trajectories can lead to an inbound motion (increasing identification with), an outbound motion (decreasing identification with) or a peripheral motion (no movement) (Jackson and Seiler, 2013).

For each of the girls whose narratives are told above, their developing physics identities can be described using the notion of trajectory. Rose and Charlotte started from a position of thinking they would choose to study physics post 16 but in the end did not; an overall outbound trajectory. For Charlotte, her identification with physics did not become outbound until she actually started to study for her A-levels and then she only did not choose physics because 'that's just because I preferred other subjects'. Up until then, she had had a fairly stable relationship with physics and she did not identify any particular moments when her identification had changed. For Rose, her outbound trajectory started when she made a firmer decision about what she wanted to do for a future career. This career goal changed from being 'just something with science' to wanting to study medicine. Alongside this firming up of a future career goal, came Rose's relationship with her physics teacher and her deciding that she would be more likely to achieve top grades in chemistry and biology rather than physics. Rose felt that she would only be successful in physics if taught by this teacher and that there was no guarantee that she would be taught by him for her A-levels.

Indiana's physics identity trajectory is one that changed dramatically with one particular incident. At the start of the research, Indiana was not thinking of studying physics post 16. Her interests were with mathematics and product design. She had an outbound trajectory. At some point, but this was not told to me, she decided that for her future career aim of working in product design, it would be a good idea if she studied physics post 16. She was a high attaining mathematics student, having taken her GCSE a year early and gained an A^* and she was predicted to attain a grade A for physics. At this moment, she had moved her trajectory towards in inbound one. She spoke to her physics teacher about taking A-level physics. He told her to reject the idea as she would not be successful. The trajectory changed again, very much in an outbound direction and with Indiana having a very negative attitude towards physics.

The final narrative is about Scout. She started with an outbound trajectory for physics but an inbound one for other sciences. The overall directions of these did not change over the time I spoke to her, but they did undergo 'ups and downs'. These related to her interactions with her teachers and her peers. At times when Scout did not receive the feedback and reassurance from her teachers that she was succeeding in science, there would be a down, outbound, movement. When she felt her peers were thinking that she was weird for liking science and mathematics were other moments of outbound movement. However, at other times when she felt she was smarter than her peers (in science and mathematics) an inbound movement occurred. Other movements back up, or in an inbound direction, were when she felt good that she could be successful at science and mathematics even though she was a girl; when she did get something right that others in her class did not and when she could pass on her knowledge.

These narratives show how important it is to look at physics identity as a whole. We can identity factors that will influence an identification with physics, but these narratives show how individual the effect of those influencers can be. For some people, a sustained direction of trajectory along a physics identity will be established following a positive, or negative, influence. For others, the trajectory will fluctuate with many influencers causing both inbound and outbound movements, often dependent on how much impact a particular influencer has on the overall identity development of that person, since physics identity is just part of an overall identity

.

Chapter 8 Conclusion

Introduction

The 'problem' of girls in physics has worried researchers, politicians and people working in physics for a number of years, at least since the 1970s. Early research on 'the problem' focused on the differential involvement of girls and boys in physics and the differential achievement of boys and girls in physics at 16 (Bennett, 2003). As further research was carried out, it again mainly focused on defined areas to explain why girls did not choose to study physics (or in most cases the research was on science in general rather than just physics).

In this study I worked on two research aims. These were:

1. to interrogate the current literature of identity and self efficacy to develop definitions of physics identity and physics self efficacy and then to develop a theoretical model linking the two
2. to explore what physics identity and physics self efficacy meant for girls in school years 9-11 and produce narratives to examine how these impact on future subject choices.

In order to try to answer these questions I carried out an extensive literature review (described in Chapters 2 and 3) and I chose a mixed methods methodology using a funnelling approach to participant selection to investigate the relationship of physics identity and physics self efficacy for girls in years 9-11. This funnelling approach started with a questionnaire given to 202 girls in years 9 and 10 at two schools. From the responses to these questionnaires 43 girls were selected to participate in small group interviews. Finally, narratives were developed for four girls from their discussions in the small group interviews, and for three of them, a further one-one interview.

In this chapter, I draw together the outcomes from these three data gathering methods. For each of the identified outcomes, I discuss what my research shows and I look at the implications of these outcomes and suggest how they can be used to understand how girls come to make choices around physics and how to change practices to encourage more girls (and boys) to choose to study physics post-16. The research outcomes also include the novel methodology I used and the theoretical frameworks developed to use in this study. The previous research in this area focused on 'the problem' of girls in physics as one that the girls themselves had or one that schools and the physics industry perpetuated. The limitation of seeing the lack of girls choosing to pursue physics as 'a problem' will be discussed in the section on theoretical frameworks. I also reflect on the methodology used in the study and possible limitations of the choices made. I conclude with suggestions for future study.

Research Outcomes

Outcomes from the questionnaire results, the small group interviews and the narratives are described below. Where the outcomes confirm previous research this is noted by citing relevant sources and, where new contributions to the literature are made, these are discussed in more detail. These new contributions are:

- teacher – student interactions
- the discourse of achievement
- similarity and differences between physics choosers and non choosers
- complexity and interrelationships of figured worlds.

For each of the identified outcomes, after I have discussed the contributions to knowledge, I outline recommendations and implications.

Making choices

The girls chose subjects to study in the future because they were interested in them (Boe 2012). The girls were more likely to prefer biological sciences to physics (Jenkins and Nelson, 2005) and were more likely than boys to say that they were thinking of choosing to study humanities subjects post-16 (Ryan, 2001; Pike and Dunne, 2011). Girls chose subjects to study post 16 because they felt they were needed for future careers (Cleaves, 2005) and this was especially the case for those who were thinking of choosing physics (Boe et al., 2011).

Choosing a future career is part of developing one's identity. The career choices made are often one of the first things that people use to describe themselves (i.e. I am a teacher, I am a doctor, I am a film maker etc.). From the questionnaire results, more girls made subject choices based on future careers than did boys. Of those students who were thinking of choosing physics, 57% of year 9 girls cited career as a reason for choosing it compared with 36% of year 9 boys and for year 10 girls it was the reason 44% gave compared with 29% of year 10 boys. I suggest that this focus on careers is because girls make decisions about what career to pursue sooner than boys and so choose subjects with this in mind. There is not enough data here to definitely conclude that that this is the case, but this was a trend shown by this data. Further research would be needed to investigate this factor, and to see whether these career decisions are fixed at this early age and what information was used to inform these choices.

The girls in this study were predominantly from White, middle class backgrounds. These families would encourage their children to choose professional careers. This could be linked to why girls in this study were already choosing subjects linked to future careers.

Girls thinking of choosing physics reported that they came from scientific families and so were exposed to scientific language in the family (Olitsky, 2006). These girls would be aware that choosing a scientific career was suitable for them because at least one of their parents also had this type of career. This trend has also been observed in the ASPIRES project (Archer et al., 2013). These results could indicate that future scientists will only be recruited from those families who are already familiar with science and so encourage their children to pursue a similar career.

Girls who were thinking of choosing physics post 16 described it as interesting but also difficult. Linking physics with difficultly is part of the commonly held belief that physics is hard, masculine and objective (Francis, 2000). This stereotypical image of physics as being hard, masculine and dominated by White, middle class males was acknowledged by the girls as something that did deter some from choosing it (Ryan, 2011; Francis 2000). They said that this should not be the case; that subjects should not be seen as gendered and that girls should not be seen as any less feminine if they chose to follow careers in what society perceived as masculine areas. However, all girls did make 'slips' (Baker and Leary, 2003) when talking about this topic, maybe showing how difficult it is to move away from messages that form an early part of identity development. These wider societal influences on choices need to be tackled by schools and teachers. Raising awareness of why these should not be used as reasons for making choices should form part of careers education in schools.

Teacher – student interactions

The work of Osborne and Collins (2001) highlighted how much pupil's interest in science classes was influenced by their teacher. They reported that pupils in general said that their interest in science was raised by teachers who made their lesson 'fun' and that girls in particular responded well to teachers who devoted time to clarification of content and who built up a good relationship between themselves and pupils. My findings support these claims, add colour and also draw attention to one aspect not highlighted in the literature before, that of the impact of non subject specialists.

Teacher – student relationships and how they impact on physics identity and physics choices were discussed by all the girls in the group interviews (see Chapter 6). The narratives, described in Chapter 7, clearly demonstrated how teacher – student relationships impacted on individuals. These relationships could have both positive and negative influences, so teachers need to be fully aware of how their actions, both in a classroom and generally with students, can affect girls' physics identity work.

The majority of girls described a physics classroom as following 'usual school physics' (following Boylan 2010). These physics classrooms are being reproduced throughout schools all over England (if not the world) and many people would recognise them as such. Rose, in contrast, described her physics classroom as being much more collaborative and that she felt this had greatly enhanced her relationship with physics. However, it was the atypicalness of this physics classroom that in the end resulted in Rose not choosing to study physics post 16. Even though this collaborative approach to learning physics resulted in Rose having an inward trajectory for physics identity at his time, this trajectory, in her view, could not be sustained if she continued to study physics without this teacher. Her physics identity was dependent on how the teacher taught physics. She did not feel that she could sustain her physics identity in a 'usual school physics' setting.

Another aspect of 'usual school physics' that was highlighted by the girls, and in particular Scout, was that this type of classroom was often perceived as a competitive classroom. Scout felt that this was particularly so in the top set. She did not feel that in this type of classroom the teacher gave her enough feedback and reassurance that she was succeeding in science and she did not feel that she was able to ask for clarification if she was unsure. This resulted in a lowering of her self efficacy, a constituent part of her identity.

The girls in this study described their best teacher, irrespective of subject, as those that took an interest in them, both for their subject but also overall. These teachers not only saw the girls as being part of the figured world of the subject they were teaching but that that figured world formed a part of the girls' overall figured world. Indiana, in her narrative, described how her physics teacher focused solely on the figured world of physics and how he acted as a gatekeeper to that world. Since he did not feel that Indiana, and the other members of her class, were capable of fully participating in the figured world of physics, he closed the door to them. Indiana described how this had a significant negative impact on her physics identity.

Subject knowledge is important and has been highlighted by the Institute of Physics (2012) in their work to encourage more physicists to become teachers. Teachers who are subject specialists can instil a love of their subject by their own strongly positive identification with that subject. Contrasting with this I also found that some of the girls in year 9 at Browning school reported that they did not feel as confident to enjoy and take an interest in a science subject when taught by a teacher who declared that they were teaching outside of their specialism. It was not just the teachers' perceived lack of subject specialist knowledge that the girls discussed, but the manner in which they talked about the subject if it was not their specific area of specialism. The girls felt that if the teachers were saying that they were not interested in the subject then they should not be too. One girl commented that her best science teacher was one who she did not know which particular area he was a specialist in; he had taught all areas with the same enthusiasm and knowledge and he had shared this with the class.

The Institute of Physics has also worked to improve the subject knowledge of non specialists with continuing professional development interventions. These 'solutions' are to be welcomed, but they only cover half the story, since it was not just subject knowledge that the girls highlighted here as an issue; it was how teachers themselves identified or otherwise with the subject and how they expressed that to their students that was significant. Negative messages from teachers demonstrated by lack of enthusiasm and comments such as 'I'm a biologist so I don't know how to do that (in physics)' were shown not to help to develop a positive identification with the subject. Further work would be needed to discover how robust this finding is.

This discussion about non specialist teachers highlights the issue as to whether teachers of science subjects should be thought of as science teachers or as teachers of biology, chemistry and physics. Related to this discussion is that of whether the science subjects should be taught as the separate subjects or as combined science and at what point in secondary education this differentiation, if needed, should be made.

Recommendations and implications

The implications of these findings are not just for the recruitment and training of science teachers but also for the management of the schools involved.

When prospective science teachers are being trained, they need to be made aware of the impact that their own negativity can have on students and how positive enthusiasm and interest for all subjects can have an energising and positive influence. This is part of their own identity work towards becoming not just a scientist but a science teacher. This should form part of their professional development and be highlighted in their professional portfolio. This highlighting of the impact they can have on students should not, however, just focus on their subject knowledge, but on all aspects of their interactions with students. They need to be made aware that the figured world of the subject they teach is only one of the many worlds that interact together in the overall figured world of that student and how all these figured worlds interplay in an individual student's identity work.

Schools, when recruiting new teachers, need to be aware whether they are looking for subject specialists or for general science teachers who have a positive attitude and enthusiasm for all science subjects. This should be assessed during the interview process. Whether schools are looking to recruit subject specialists or general science teachers will depend on how the science curriculum is managed within that school. Schools will need to be clear about whether they teach the separate sciences using subject specialists or whether they want a more flexible work force. They will also need to decide when they differentiate between the sciences (both the schools in this study taught the sciences as separate subjects from year 10). If this is the case, they need to ensure that when teachers teach outside of their own stated specialism that they do so with enthusiasm. This should form part of the internal appraisal system.

The discourse of achievement

As described in Chapter 2, one of the stereotypical images of physics is that it is hard (Ryan, 2011). The girls did describe physics as hard but this was only part of a discourse linked to difficultly and choice. Even girls who were very successful in GCSE physics did not choose to pursue it. The stereotypical image of physics as hard is a discourse that is generally held by society. Maintaining this discourse allows those who work in the physics industry to hold a certain status; they have been successful in a hard subject so therefore they must have a higher level of intellect than the majority of society. Opening up physics to a wider range of people by encouraging more students to study it post 16 would lower this high status and those already in the industry may feel that their position in society is diminished.

The girls also described how they felt that they had to achieve the best possible outcomes in their studies and that they chose to pursue subjects that would allow them to achieve highly easily. They did not feel that choosing physics would help them to achieve these goals. I termed this the discourse of achievement.

The discourse of achievement is linked to self efficacy; a person's belief in their ability to perform tasks at certain levels. Boys demonstrated higher self efficacy than girls (Brtiner and Pajares, 2006). One factor that can affect the level of self efficacy is that of seeing similar others perform a task. For the girls in this study, they reported that they did not feel that their self efficacy was enhanced by seeing similar others' achievement; in fact they felt the opposite, that their self efficacy was reduced. This was especially the case when test and examination results were shared in the class. Hearing what level others had achieved, even if they had achieved highly themselves, did not make them feel that they would be able to repeat this achievement in the future and in some cases reduced their belief in their ability.

The discourse of achievement, that I identified and described in Chapter 6, however, goes further than just self efficacy. It is also linked to perceived hardness of subjects; but again goes further. The discourse of achievement combines both of these but goes further so as to look at all aspects of achievement and how it is measured. The discourse of achievement is part of modern society's requirement that everyone should achieve in examinations as highly as they can and in as many subjects as they can. Society wants students who are good all rounders; they do not want students who can achieve a high grade in a 'hard' subject like physics but who cannot achieve that same level in all the other subjects they study. Achieving highly in a 'hard' subject takes more effort and a higher self efficacy than for a subject that is perceived as easy and one in which it is easier to be more successful. For many girls the need to be successful outweighed their need to choose subjects that they enjoyed, especially if the subjects they enjoyed were those that they felt were hard. Girls did not feel that they were meeting society's expectations if they concentrated on those 'hard' subjects they enjoyed but where they did not feel that they were 'guaranteed' to achieve high grades.

Recommendations and implications

In order to overcome the pressures placed on students by this discourse of achievement, we need to encourage students to be prepared to take risks. We need to change the emphasis in education from 'results mean everything'. We need to encourage an emphasis on learning for enjoyment and that learning is a continuous process that does not stop once a subject has been 'dropped' from a student's study list. The change away from a 'results mean everything' discourse needs to come from government. We need to question as to whether this discourse is actually leading to an improvement in schools, teaching and results or whether it is just adding to the pressures on students, teachers and schools to perform in ways that do not actually enhance learning but just meet targets of performance set by government.

Change is also needed in society. Society needs to acknowledge differences that mean that not all students can gain a certain level at a given time in the subjects they study at school. We, parents and teachers, need to encourage all students to achieve to their best in any subject they choose to study, not a predetermined level set by external agencies.

Similarity and differences between physics choosers and non choosers

Analysis of the data from the questionnaires and from the small group interviews showed much agreement with previous work. In questions asking about teachers and lessons[36] possible choosers of physics were generally more positive about their teachers than non choosers. For lessons, the views were fairly neutral with only one area, practical work, being highlighted as adding enjoyment to the subject by all groups of students (Osborne and Collins, 2001). Overall, the data from the questionnaire generally showed that there was a difference between possible choosers and non choosers of physics in the answers they gave to all the questions, with the possible choosers giving more 'positive' responses. The results from the questionnaire do, of course, show that not all girls who are thinking of choosing physics will always give the same responses, but some trends can be observed that show differences between possible choosers and non choosers. When looking at the small group interview data, I expected that these same trends between possible choosers and non choosers would be observed and that the interview data would explain why these variations existed. This was not the case.

In the majority of themes explored in the interviews, there were no discernable differences between those girls who had originally expressed that they were

[36] Science teachers and lessons in year 9 and physics teachers and lessons in year 10

thinking of choosing physics for A-level and those who had not; between the different year groups and between the two schools. I would have expected, based on previous research and my own data from the questionnaires, that girls who were not thinking of choosing physics would have given more negative comments about their relationship with physics and would have been more likely to hold stereotypical views about physics than those girls who had expressed an interest in choosing physics in the future. When I actually looked at the quotes once they had been ordered thematically, it was noticeable that there was in fact very little difference between the different groupings of girls. The only area where differences were marked was that those girls who were thinking of choosing physics or other sciences reported having parents with a scientific background whereas those not thinking of choosing physics or other sciences did not (see early section for discussion of this).

These findings are only for this group of girls who were a subset of the girls (and boys) who completed the questionnaire and may not be reproducible for a larger set of girls or ones from different socioeconomic backgrounds. The majority of girls involved in this research were from a White, middle class background. However, it does show that care needs to be taken when using just survey data alone to describe what 'the problem' is with girls and physics.

Why then were the differences observed in the questionnaire not repeated in the interview data? The questionnaire data gives a snap shot of what the girls thought at that time. This could have been influenced by recent experiences in science and physics; by which lesson they were completing the questionnaire in; by putting the answers expected rather than the 'real' ones and by the limits imposed on the answer categories (e.g. how much can you only agree, disagree or not with a broad statement about your science teachers, especially if you have more than one). The interviews gave the girls the opportunity to talk in more depth about some of these areas and therefore, possibly, to reach further beyond stereotypical or expected answers. An example from my own schooling springs to mind to demonstrate this further. I never enjoyed studying English. However, my O'level English teacher was very good; she delivered interesting and stimulating lessons; gave extensive and detailed feedback on the essays I wrote;

and I had a very good interpersonal relationship with her. However, this did not make me any more interested in the subject as a whole, and these lessons, although interesting, were not ones that I particularly looked forward to. If completing a questionnaire about English lessons and the subject in general, I would have given fairly negative responses, but in an interview, I would have spoken about how much I respected the teacher and how interesting she did make the lessons. I feel that a similar effect has been observed with the girls I interviewed about their relationship to physics.

Recommendations and implications

These findings show how complex the reasons are why we choose or don't choose to study a subject further and how they cannot be ascertained easily by using just questionnaires. For teachers and schools who are trying to encourage more girls to study physics, using questionnaires to find out what they think of their physics classes and teachers can form the start of an intervention programme. This intervention programme needs to be for all students. This research has shown that there is actually very little difference between future choosers and future non choosers of physics. If only certain girls (i.e. those who express an interest in choosing physics at a given time) are chosen to participate in an intervention programme to improve the level of physics choice, then teachers will be excluding girls who may in fact go on to chose physics but who did not show an interest at that time. Teachers are making a choice for their pupils; they are acting as gate keepers to a subject rather than opening it up to all. Many girls may not express an interest in physics if they do not know what careers it can lead to (as described earlier, girls have a career focus from an early age) and it may be exposure in an intervention programme to the possible careers physics can lead to that could encourage more girls to study it. Limiting the exposure to such an intervention programme will also limit the number of future physics choosers.

The results of a questionnaire can inform schools and teachers of what they need to do in their lessons to improve progression, but they need to do this as part of a more extensive programme that looks at all aspects of choice. Teachers also need to be encouraged to use their own stories of how they came to choose subjects to develop activities for students. Physics teachers sharing their stories can be used to illustrate the many ways a person can identify with physics.

All of this needs to be framed by identity development; not only of an identification with physics but of a girl's (or boy's) overall identity work that takes place during their school years. Further research needs to take place looking at how subject choices and identity development are interlinked and how these both develop and change over time. A longitudinal approach using interviews and a narrative interpretation would give much rich data about this. Reflective interviews looking at life stories and how a person's choices of careers and subject interests changed over the years and the factors that influenced those changes would also give insight into how choice forms a part of identification with physics.

Complexity and interrelationships of figured worlds

The contradictions and variations in how we describe our relationships with a subject are particularly noticeable when you look at an individual's reasons for choosing or not choosing a subject and the factors that influence them. Taking a more holistic view, and investigating how these influencing factors come together, led me towards creating narratives to look at individual girls' relationships with physics. These narratives explore how all these factors, taken together, impact on choices. Some factors can have a bigger influence than others. The impact of different factors can be similar or different depending on how an identification with physics develops within a person's overall identity. These narratives are both 'typical' and individual; and they clearly show how looking for one answer to 'the problem' is not practicable.

The main place where young people learn physics is in the figured world of the physics classroom. This physics classroom was described in a variety of ways by the girls in this study. Some of them described a classroom which was dominated by competition; some a classroom where only a limited range of teaching and learning methods were used as opposed to some where a wide variety of methods were used; some where the teacher made sweeping assumptions about his pupils' ability and interest in physics; and some a classroom where cooperation occurred between the students and the teacher. The girls' involvement in these figured worlds clearly influenced them developing different identifications with physics. Those where cooperation and a variety of teaching and learning methods were used resulted in the most positive identifications with physics and those with competition, limited teaching and learning methods and a dominating teacher, to a less positive identification with physics. My study only gives a limited description of the figured worlds of these classrooms and a more in-depth study of this figured world, by using extensive lesson observations, would need to be carried out to further describe the link between the figured worlds of the physics classroom and identification with physics.

This classroom figured world sits within and alongside other figured worlds that make up the student's day to day world. The individual figured worlds of the different school subjects fall within the wider figured world of the whole school; which could be described as the school culture. The narratives described in Chapter 7 are for girls who all studied at the same school. In Chapter 7 I explained how I had come to choose these girls. As outlined above, in general there were no observable differences between the responses in the small group interviews from girls at both my study schools. However, there must be some differences between the cultures at these schools in order for the girls who I chose for the narratives to all come from the same school. On the face of it, the schools are very similar; they are successful schools with outstanding Ofsted reports, they serve the communities on the outskirts of similar towns; and the pupils are predominantly White and middle class. The differences must therefore be within the school culture. Researching how the whole school culture can influence identification with physics and so lead to certain choices would be interesting but difficult.

Recommendations and implications

Choices are considered to be part of identity work. What we choose to study forms a big part of who we are. Therefore, those factors identified in Chapter 2 that influence choice can also be considered to influence identity development. Factors that influence the level of self efficacy, reported in Chapter 3, will also influence identity development if we believe, as I have argued, that self efficacy is a component of identity. The overall effect will result in the individual having a more positive or more negative physics identity, leading to an inbound or outbound trajectory (Barton et al., 2013; Jackson and Seiler, 2013). The stronger the identity, the more likely they are to choose to study physics post 16.

The four narratives described in detail in Chapter 7 show four different trajectories of physics identity and show how differing factors affect those trajectories at differing times. They illustrate how coming to understand physics choices needs to be placed within the context of an identification with physics. For those people who can influence choices by influencing identity work, an understanding of how their influence works alongside those of other factors is important. It would be impossible for those who work with students to produce an identity trajectory for each student or for each student's relationship with each subject they study. What is important is for those people to have an understanding of how different influences can affect students' identity development and how these impact on choice and that there is a very complex interrelationship between all the factors.

Researching Girls and Physics

The research outcomes discussed in the section above focus on those outcomes from the data gathered in the questionnaire, the small group interviews, and created into narratives. This section focuses on the research outcomes from the methodological processes developed to research the aims outlined above and the theoretical framework developed to discuss the findings.

This section of the chapter also includes a discussion of the limitations of the research and suggestions for future directions and further research.

Methodological processes

Physicists (and other scientists) like numbers. Being able to say that X percent of girls choose to study physics post 16 because of Y reason feels comfortable. Much of the previous research into 'the problem' of girls and physics has been done in a quantitative paradigm which makes it more approachable for teachers who have this scientific background (for example surveys carried out by Stewart, 1998; Spaull et al, 2003 and 2004; Bennett and Hogarth, 2009).

Research focusing on identity development in science and mathematics has been carried out using qualitative methods. These include individual interviews (for example Brickhouse, Lowery and Shultz, 2000), group interviews (for example Pike and Dunne, 2011) and narratives (for example Sfard and Prusak, 2005). This research gives insight into why girls do and do not choose to study physics and about how their relationship with science (and physics) develops over time.

The methodological approach used in this project I have described as a mixed methods methodology with a funnelling approach to participant selection. At the start of the project, a questionnaire was given to 458 year 9 and 10 pupils at two schools who had been identified by their teachers as having the necessary attainment to be able to progress onto A-level physics if they so chose. This was followed by semi-structured small group interviews with 40 girls. Following on from, and using the data collected in these interviews, I selected four girls whose narratives I wanted to tell. I interviewed three of these girls further to gather more data for these narratives.

As outlined above, using qualitative methods to investigate 'the problem' of girls and physics is less common that using quantitative work. There have been recent examples of following up large scale quantitative inquiries with smaller scale qualitative interviews, usually individual interviews (for example the ASPIRES project (Archer et al., 2010, 2012 and 2013); and the UPMAP project (Mujtaba and Reiss, 2012a and 2012b)). Using small group interviews as the main data gathering tool to get a rich, thick description as to how identity influences choices in physics is rare, if not novel.

My work shows that this approach can be used in this field. Using narratives as a methodological approach to describe how science identities develop is becoming more used in research in the US. Using this approach to investigate developing identifications with physics and how this impacts on choice is again rare, especially in the UK, and my project contributes to this growing body of work exploring the use of narratives. The narratives described here are not generalisable, but they are recognisable. They give a picture of how for these girls their identity with physics impacted on their decision not to study physics further. Using a narrative approach also allows us to investigate how a relationship to physics is filtered through all the other relationships that occur when identity work is taking place. Identity and narrative can potentially give us a holistic view of how choices as to whether to study certain subjects or not are made.

Theoretical frameworks

Blickenstaff (2005) identified nine explanations that had been put forward to explain 'the problem' of girls and physics and Murphy and Whitelegg categorised the literature discussing girls and physics and/or science into six groups.

Table 8-1 Comparing Blickenstaff with Murphy and Whitelegg

Blickenstaff (2005)	Murphy and Whitelegg (2006a)
Biological differences between men and women	Interests, motivation, course choices and career aspirations

Girls' lack of academic preparation for a science career	Relevance and curriculum interventions
Girls' poor attitude toward science and lack of positive experiences with science in childhood	Teacher effects
The absence of female scientists/engineers as role models	Single-sex schooling and groupings
Science curricula are irrelevant to many girls	Measures and perceptions of difficulty
The pedagogy of science classes favours male students	Entry and performance patterns in physics: the impact of assessment processes and techniques
A 'chilly climate' exists for girls/women in science classes	
Cultural pressure on girls/women to conform to traditional gender roles	
An inherent masculine worldview in scientific epistemology	

In my own review of current literature in Chapter 2, I categorised it into five groups which were:

- general attitudes to science and physics
- subject choices linked to future careers
- the influence of teachers and teaching on subject choice
- the influence of others on subject choice
- the image of physics.

These five groupings offer a new framework for discussing the issues that contribute to 'the problem' of girls and physics.

A more recent trend in science and physics educational research has been to look at identity. This body of research, although using a variety of definitions of identity, has moved the focus away from separately identified causal factors to looking at how the development of an identification with science (or physics) forms part of a young person's overall identity. Linking subject choices to identity forms part of what Holmegaard et al. (2012) describe as the Scandinavian tradition of investigating choices where they see choices as forming part of a students' construction of an attractive identity. This research uses the notion of a developing identification with physics as a basis for a student's choice as to whether or not to study physics post 16 or not. However, research using identity as a basis for explaining future physics choices is limited and my study has made a contribution to addressing this gap in the literature.

Self efficacy is recognised as a psychological phenomenon and research into science and physics self efficacy has been focused in the quantitative paradigm (for example, Brtiner and Pajares, 2006; Haussler and Hoffmann, 2002). Some recent work by Usher (2009) has used a more qualitative approach to investigate mathematics self efficacy. As described in Chapter 3, my belief is that self efficacy is one component of identity and so the two should be researched together.

My proposed theoretical framework for using identity to research future physics choices is based on the description of identity as a process where we come to think we know who we are, we think we know who others are, that they think they know who we are and that we think we know who others think we are. This work towards our identity is carried out in figured worlds (Holland et al., 1998). It is in these figured worlds that we come to recognise ourselves and others as certain types of people. Our belief in how well we can learn or perform actions; our self efficacy, is part of this coming to know ourselves. The choices we make are part of us coming to know who we are. Using a framework based on identity and self efficacy development within the figured world of physics to investigate reasons for choices is a novel and powerful way of researching 'the problem' of girls and physics.

Throughout this research project I have used the term 'the problem' of girls and physics. Previous research has focused on 'the problem' of girls in physics as one that the girls themselves had or one that schools and the physics industry perpetuated. Using the term 'the problem' implies that there is a simple answer to curing it. However, the many reasons proposed for the cause of 'the problem' and interventions used to solve it have not resulted in a solution or more girls choosing to study physics post 16. This research study has shown that 'the problem' of girls and physics is a complex one. Using identification with physics as a lens for investigating choice provides a new contribution to the debate. There is no quick fix to solving 'the problem' of encouraging more girls (and more boys) to choose to study physics post 16. Using this more holistic view should also make us realise that 'the problem' is not a good way of describing the issue – whose problem is it? Perhaps this is the question that needs to be answered first.

Limitations of the research

At the start of this project I proposed to carry out a two school case study. The methods of data gathering for this case study would include a questionnaire, small group interviews, lesson observations, possible informal interviews with teachers and use of supporting evidence. This would have meant that data to answer the research questions would have come from both students and teachers and my own observations and would have allowed triangulation to take place. The reluctance of the teachers at one of the schools to allow me to observe their lessons lead to my decision to focus on narratives. Therefore the research is student centred; the teacher voice is suppressed.

The schools chosen for this study were both situated in areas where the majority of their students came from White, middle class backgrounds. This does not mean that the data is any less meaningful; it just means that it is for a particular group of girls. This means the narratives given are typical but not generalisable. For a more generalisable collection of narratives, girls from a range of socio economic and ethnic backgrounds would need to be interviewed.

The questionnaire was given to 458 students in year 9 and 10 at two schools. This gave me background to the thinking of the students in these two schools and two year groups, but when I sub divided the data into year groups and those who were thinking of choosing physics and those who were not, some very small groupings resulted. This meant that valid statistical data could not be reported. To see whether the trends I did observe in the data from the two schools is typical a larger sample would need to be used.

Forty three girls were invited to participate in the group interviews. Forty girls participated in at least one group interview with 31 participating in all three. As outlined in Chapter 6, even though I had an interview question schedule, I did not rigidly stick to this and allowed the interviews to develop as discussions when the girls had plenty to talk about. This meant that not all the questions were answered by each group of girls.

During the discussions, even though I ensured that all girls had the opportunity to contribute to the discussions, they did not always want to. When transcribing the interviews, it became apparent that in some instances some of the girls had been very quiet and only contributed agreements with comments rather than making their own. When choosing examples of talk, this meant that comments were not chosen from all the girls. However, on re-reading through the original transcripts to check that I had got the overall feel of the interviews correct and that I had not missed out any important issues, especially if girls had contradicted what I had summarised, I believe that I had managed to capture the general feelings of all the girls involved, even if I had not quoted from them directly.

This analysis of the data showed that the group interviews could be used to illustrate points made on the questionnaire and give a thicker description of some of the findings, but that they did not fully capture how girls' physics identities, including their physics self efficacies, developed and changed during their interactions with the figured world of school physics over the time that I interviewed them. The interview data, as with the questionnaire data, gave snapshot views (as illustrated in the methodology chapter (Chapter 4) when I described how the girls reflected back on the discussions made in the first interview when they reviewed it). As Barton et al. (2013) and Jackson and Seiler (2013) describe, identities can be thought of as developing along a trajectory. To investigate how physics identities developed, I chose five girls (which became four – see Chapter 4) whose identification with physics had developed over the course of the interviews.

The narratives given here are for four girls, three who had already made the decision not to study physics post 16 and one who indicated that this was what she was thinking of doing. To give a more rounded picture of how identification with physics can influence the decision to choose physics it would have been good to have had at least one narrative for a girl who did in the end choose to study physics.

In all of this research I, myself, can be a factor that influences the data collection. Once I started the interviews, I made the girls aware that I was a teacher, although I had never taught in schools, and that I was interested in the subject of girls and physics. This could have influenced the girls to give me the responses that they thought I wanted to hear. The interviews were a co-construction between the girls and me. My background as a woman with an interest in gender equality in the sciences meant that I needed to be aware that I did not allow my prejudices and preconceived ideas to impact on the questions I asked or the way in which I asked the questions so as to only get the information I needed to support my ideas. I needed to be open to all responses, even those which were the opposite of mine. When analysing the data, I needed to be aware that I was telling the story of the girls, all be it my interpretation of their stories. I tried hard to ensure that it was their voice, not mine that was being told. With any study researchers need to be aware of their own influence both on the collection and analysis of data.

Future directions and further research

The work started for this thesis opens up some new avenues for future work. As outlined in Chapter 2, there is a shortage of research that has been carried out investigating girls' experiences of science and physics in schools in England and how these experiences inform future aspirations (and so future choices to study physics post 16) (Murphy and Whitelegg, 2006a). Research on choices in English schools has had a focus on understanding how students' background, especially their social class, can affect choices. Using identity as a focus for understanding choices has been the focus of choice research in Scandinavia (Holmegaard et al., 2012). Research on physics identity and science identity in general has mainly been carried out in the US with pupils from poor, urban backgrounds. Some recent research as part of the ASPIRES project has looked at science identity formation in English primary schools. There is therefore still a large gap in the research literature; both looking at physics identity in general and how physics identity is linked to choice in English schools.

Narratives have been used to produce a more in depth picture of how identities develop over time. The narratives here have been produced by talking to a small number of girls over a period of time. Narratives can also be produced by using retrospective techniques. It would be valuable to see if narratives from women already working in the physics industry could be used to confirm that physics identity and physics self efficacy and the factors that influence them are linked and that their choice to study physics could be explained in a similar way to the explanations used in the narratives in this research.

My four narratives focus on girls who did not in the end choose, or propose to choose, to study physics post 16. Only a very small number of the girls in my research actually did choose to study physics post 16 (I can only identify two). As has been shown here, it is difficult to identify girls at an early age who are going to choose to study physics post 16. Therefore, it would be interesting to repeat this study, using just a narrative approach, and follow more girls who were thinking of studying physics during their pre-16 schooling in the hope that some of them would actually choose physics.

More work also needs to be done to investigate how the school culture, within which a girls' identification with physics mainly develops, has an impact on that identification. It would be helpful to carry out a more ethnographic approach to the research by spending much more time following identified girls throughout their school life seeing how they interact with their friends and peers, their teachers and how the overall culture of the school impacts on their daily life.

The Contribution of the Study

This research project was carried out to answer two research aims. These were:

1. to interrogate the current literature of identity and self efficacy to develop definitions of physics identity and physics self efficacy and then to develop a theoretical model linking the two
2. to explore what physics identity and physics self efficacy meant for girls in school years 9-11 and produce narratives to examine how these impact on future subject choices.

A theoretical framework has been proposed where self efficacy is believed to form part of identity and where identity is described as a process where we come to think we know who we are, we think we know who others are, that they think they know who we are and that we think we know who others think we are. Identity work, or coming to recognise ourselves and others as certain types of people, is carried out in figured worlds. The choices we make, especially those around what subjects to study post 16, are part of us coming to know who we are.

To explore how physics identity and physics self efficacy impact on future subject choices of girls in school years 9-11 I used a mixed methods methodology with a funnelling approach to selecting participants. Using this approach I created four narratives which show four different trajectories of physics identity and show how differing factors affect those trajectories at differing times. They illustrate how coming to understand physics choices needs to be placed within the context of an identification with physics.

Whilst carrying out the data collection, many of the factors that have previously been identified in the literature as impacting on choice were confirmed. Four new contributions to the debate were identified. These were:

- teachers who are not physics specialists
- the discourse of achievement
- similarity and differences between physics choosers and non choosers
- complexity and interrelationships of figured worlds.

Evidence from the data to support these new contributions was discussed.

Overall, my research shows that tackling 'the problem' of girls and physics can only be done by taking an holistic view of how an individual's identification with physics develops within the wider worlds in which they live and by changing many of society's views on physics and education in general.

Concluding Remarks

In Chapter 1 I introduced the reader to myself – who I am, who I think I am, and who I think others think I am. My identity has changed during the time of this research; I have worked on my identity as a social scientist within the figured world of educational research. My trajectory has been an inbound one, but with moments of outbound movement when my self efficacy has been greatly reduced.

I have been very fortunate that the girls I selected to talk to me in the small group interviews were willing to share their thoughts and feelings about physics with me. Without them I would not be able to make the contributions to move the debate about 'the problem' of girls and physics forward as I have done.

The issue of how we attract more girls into physics is a complex one and needs to be addressed, not by proposing quick fixes to 'a problem' that can be solved, but by looking at the wider picture of how physics forms a part of the many figured worlds that girls inhabit.

References

Acker, S. and Oatley, K. (1993). Gender issues in education for science and technology: current situation and prospects for change. *Canadian Journal of Education*, 255-272.

Agar, M. (1996). *The Professional Stranger: An Informal Introduction to Ethnography*. Academic Press.

Aikenhead, G. S. (1996). Science education: boarder crossing into the subculture of science. *Studies in Science Education*, 27, 1-52.

Aldridge, A. and Levine, K. (2001). *Surveying the social world.* Open University Press, UK.

Andrews, M. (2007). Living counter-narratives. In C. Seale, G. Gobo, J. F. Gubrium and D. Silverman (Eds). *Qualitative Research Practice* (Chapter 6), Sage, Los Angeles.

Angell, C., Guttersrud, O., Henriksen, E. K. and Isnes, A. (2004). Physics: frightful, but fun. *Science Education*, 88, 684-706.

Archer, L, Dewitt, J., Osborne, J., Dillon, J., Willis, B. and Wong, B. (2010). "Doing" science versus "being" a scientist: examining 10/11-year old schoolchildren's constructions of science through the lens of identity. *Science Education*, 94, 617-639.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. and Wong, B. (2012). "Balancing acts": elementary school girls' negotiations of femininity, achievement and science. *Science Education*, 96, 967-989.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. and Wong, B. (2013). 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspiration. *Pedagogy, Culture and Society*, 21, 171-194.

Aschbacher, P. R., Li, E. and Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering and medicine. *Journal of Research in Science Teaching*, 47, 564-582.

Aydeniz, M. and Hodge, L. L. (2011). Identity: a complex structure for researching student's academic behaviour in science and mathematics. *Cultural Studies of Science Education*, 6, 509-523.

Babbie, E. (1990). *Survey research methods second edition.* Wadsworth, USA.

Baker, D. and Leary, R. (2003). Letting girls speak out about science. *Journal of Research in Science Teaching*, 40, S176-S200.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist,* 37, 122-147.

Baram-Tsabari, A. and Yarden, A. (2008). Girls' biology, boys' physics: evidence from free-choice science learning settings. *Research in Science and Technological Education*, 26, 75-92.

Baram-Tsabari, A. and Yarden, A. (2011). Quantifying the gender gap in science interests. *International Journal of Science and Mathematics Education*, 9, 523-550.

Barmby, P., Kind, P. M. and Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education*, 30, 1075-1093.

Bennett, J. (2003). *Teaching and Learning Science.* Continuum, London.

Bennett, J. and Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school student's attitudes to school science and to science. *International Journal of Science Education*, 31, 1975-1998.

Bennett, J., Lubben, F. and Hampden-Thompson, G. (2013). Schools that make a difference to post-compulsory uptake of physical science subjects: some comparative case studies in England. *International Journal of Science Education*, 35, 663-689.

BERA. (2011). *Ethical Guidelines for Educational Research.* www.bera.ac.uk.

Betz, D. E. and Sekaquaptewa, D. (2012). My fair physicist? Feminine math and science role models demotivate young girls. *Social Psychological and Personality Science*, 3, 738-746.

Bhanot, R. T. and Jovanovic, J. (2009). The links between parent behaviours and boys' and girls' science achievement beliefs. *Applied Developmental Science*, 13, 42-59.

Blalock, C. L., Lichtenstein, M. J., Owen, S., Pruski, L., Marshall, C. and Toepperwien, M. (2008). In pursuit of validity: a comprehensive review of science attitude instruments. *International Journal of Science Education*, 30, 961-977.

Blickenstaff, J. C. (2005). Women and science careers: leaky pipeline or gender filter? *Gender and Education*, 17, 369-386.

Boaler, J., Altendorff L. and Kent G. (2011). Mathematics and science inequalities in the United Kingdom: when elitism, sexism and culture collide, *Oxford Review of Education*, 37, 457-484.

Boaler, J. and Greeno, J. (2002). Identity, agency and knowing in mathematical worlds. In J. Boaler (Ed). *Multiple perspectives on mathematics teaching and learning* (p171-200). Westport.

Boe, M. V. (2012). Science choices in Norwegian upper secondary school: what matters? *Science Education*, 96, 1-20.

Boe, M. V., Henriksen, E. K. (2013). Love it of leave it: Norwegian students' motivations and expectations for postcompulsory physics. *Science Education*, 97, 550-573.

Boe, M. V., Henriksen, E. K., Lyons, T. and Schreiner, C. (2011). Participation in science and technology: young people's achievement-related choices in late-modern societies. *Studies in Science Education*, 47, 37-72.

Bohnsack, R. (2004). Group discussion and focus groups. In U. Flick, E von Kardoff, and I. Steinke (Eds). *A Companion to Qualitative Research.* Sage, London.

Bold, C. (2012) *Using Narrative in Research*, Sage, London.

Boylan, M. (2010). Ecologies of participation in school classrooms. *Teaching and Teacher Education*, 26, 61-70.

Breakwell, G. M., Vignoles, V. L. and Robertson, T. (2003). Stereotypes and crossed-category evaluation: the case of gender and science education. *British Journal of Psychology*, 94, 437-455.

Brickhouse, N. W., Lowery, P. and Schultz, K. (2000). What kind of girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, 37, 441-458.

Brickhouse, N. W. and Potter, J. T. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching*; 38, 965-980.

Britner, S. L. and Pajares, F. (2006). Sources of science self efficacy beliefs of middle school students. *Journal of Research in Science Teaching*, 43, 485-499.

Brooks, R. (2003). Young people's higher education choices: The role of family and friends. *British Journal of Sociology of Education*, 24, 283-297.

Brotman, J. S. and Moore, F. M. (2008). Girls and science: a review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45, 971-1002.

Bruner, J. (2004). Life as narrative. *Social Research*, 71, 691-710.

Buccheri, G., Abt Gurber, N. and Bruhwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education*, 33, 159-178.

Buck, G. A., Plano Clark, V. L., Leslie-Pelecky, D., Lu, Y. and Cerda-Lizarraga, P. (2007). Examining the cognitive processes used by adolescent girls and women scientists in identifying science role models: a feminist approach. *Science Education*, 688-707

Carlone, H. B. (2012). Methodological considerations for studying identities in school science : an anthropological approach. In M Varelas (Ed). *Identity construction and science education research*. (Chapter 2). Sense, Rotterdam.

Carlone, H. B., Haun-Frank, J. and Webb, A. (2011). Assessing equity beyond knowledge and skills based outcomes: a comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching*, 48, 459-485.

Carlone, H. B. and Johnson, A. (2007). Understanding the science experiences of successful women of color: science identity as an analytic lens. *Journal of Research in Science Teaching,* 44, 1187-1218.

Calabrese Barton, A. (1998). Teaching science with homeless children; pedagogy, representation and identity. *Journal of Research in Science Teaching*, 35, 379-394.

Calabrese Barton, A. and Tan, E. (2009). Funds of knowledge and discourses and hybrid space. *Journal of Research in Science Teaching*, 46, 50-73.

Calabrese Barton, A. and Tan, E. (2010). We be burning! Agency, identity and science learning. *Journal of the Learning Sciences*, 19, 187-229.

Calabrese Barton, A., Kang, H., O'Neill, T. B., Bautista-Guerra, J. and Brecklin, C. (2013). Crafting a future in science: tracing middle school girls' identity work over time and space. *American Educational Research Journal*, 50, 37-75.

Catsambis, S. (1995). Gender, race, ethnicity and science education in the middle grades. *Journal of Research in Science Teaching*, 32, 243-257.

Clandinin, D. J. (2006). Narrative inquiry: a methodology for studying lived experience. *Research Studies in Music Education*, 27, 44-54.

Clandinin, D. J. and Connelly, F. M. (2000). *Experience and Story in Qualitative Research*. Jossey-Bass, San Francisco.

Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education*. 27, 471-486.

Coe, R. J. (2012). The nature of educational research. In J. Arthur, M. Waring, R. Coe and L. V. Hedges (Eds). *Research Methods and Methodologies in Education* (Chapter 2). Sage, London.

Connelly, F. M. and Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher*, 19, 2-14.

Creswell, J. W. (2003). *Research Design* (2nd edition). Sage Publications, London.

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design* (2nd Edition). Sage Publications, London.

Cresswell, J. W. and Plano Clark, V. L. (2011) *Designing and Conducting Mixed Methods Research* (2nd Edition). Sage, California.

Czarniawska, B. (2004). *Narratives in Social Science Research*. Sage Publications, London.

Danielsson, A. T. (2012). Exploring woman university physics students 'doing gender' and 'doing physics'. *Gender and Education*, 24, 25-39.

Denscombe, M. (1995). Explorations in group interviews: an evaluation of a reflexive and partisan approach. *British Educational Research Journal*, 21, 131-148.

DeWitt, J., Archer, L. and Osborne, J. (2013). Nerdy, brainy and normal: children's and parents' constructions of those who are highly engaged with science. *Research in Science Education*, 43, 1455-1476.

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B. and Wong, B. (2013). Young children's aspirations in science: the unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*, 35, 1037-1063.

DfE (2010) Science and mathematics data A-level statistics report.

DfE. (2012). Retrieved from http://media.education.gov.uk/assets/files/xls/s/sfr01-2012t13t14.xls

DFEE (1997) Qualifying for success: a consultation paper on the future of post-16 qualifications.

DIUS. (2009).The Demand for STEM Graduates.

Eccles, J. (2009). Who am I and what an I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, 44, 78-89.

Eccles, J., Adler, T. F., Fullerman, R., Goff, S. B., Kaezala, C. M., Meece, J. L. and Midgely, C. (1983). Expectancies, values and academic behaviours, p 75-146 in *Achievement and achievement motives: Psychological and sociological approaches*, Spence, J. T. Editor, Friedman, San Francisco.

Eccles, J., Barber, B. and Jozefowicz, D. (1999). Linking gender to educational, occupational and recreational choices: applying the Eccles et al. model of achievement-related choices, p153-192 in *Sexism and stereotypes in modern society: the gender science of Janet Taylor Spence*, Swan, W. B., Langlons, J. H. and Gilbert, L. A. Editors, American Psychological Society, Washington DC.

Eccles, J., Vida, M. N. and Barber, B. (2004). The relation of early adolescents' college plans and both academic ability and task-value beliefs to subsequent college enrolment. *Journal of Early Adolescence*, 24, 63-77.

Fisher, D. and Rickards, T. (1998). Associations between teacher-student interpersonal behaviour and student attitude to mathematics. *Mathematics Education Research Journal*, 10, 3-15.

Flick, U. (2011). *Introducing Research Methodology*. Sage, London.

Flyvbjerg, B. (2007). Five misunderstandings about case-study research, p390-404 in *Qualitative Research Practice*, Seale, C., Gobo, G., Gubrium, J. F. and Silverman, D. Editors. Sage Publications.

Francis, B. (2000). The gendered subject: students' subject preferences and discussions of gender and subject ability. *Oxford Review of Education*, 26, 35-48.

Francis, B. (2010). Re/theorising gender: female masculinity and male femininity in the classroom? *Gender and Education*, 22, 477-490.

Francis, B., Skelton, C. and Read, B. (2010). The simultaneous production of educational achievement and popularity: how do some pupils accomplish it? *British Educational Research Journal*, 36, 317-340.

Freire, S., Carvalho, C., Freire, A., Azevedo, M. and Oliveira, T. (2009). Identity construction through schooling: listening to students' voices. *European Educational Research Journal*, 8, 80-88.

Frey, J. H. and Fontana, A. (1991). The group interview in social research. *The Social Science Journal,* 28, 175-187.

Gee, J. P. (2000). Chapter 3: Identity as an analytical lens for research in education. *Review of Research in Education*, 25, 99-125.

Gilbert, J. and Calvert, S. (2003). Challenging accepted wisdom: looking at the gender and science education question through a different lens. *International Journal of Science Education*, 25, 861-878.

Gill, T. (2012). *Uptake of GCE A level subjects 2011.* Statistics Report Series No 42, Cambridge Assessment, Cambridge, UK.

Gilmartin, S., Denson, N., Li, E., Bryant, A. and Aschbacher, P. (2007). Gender ratios in high school science departments: the effect of percent female faculty on multiple dimensions of students' science identities. *Journal of Research in Science Teaching*, 44, 980-1009.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, 8, 597-607.

Gomm, R., Hammersley, M. and Foster, P. (2000). Eds. *Case Study Method: Key Issues, Key Texts.* Sage, London.

Gonsalves, A. J. and Seiler, G. (2012). Recognising "smart super-physicists": gendering competence in doctoral physics. In M Varelas (Ed). *Identity construction and science education research.* (Chapter 11). Sense, Rotterdam.

Guba, E. G. (1990). *The Paradigm Dialog.* Sage, Newbury Park.

Guerra, J. B., Calabrese Barton, A., Tan, E., Kang, H. and Brecklin, C. (2012). Kay's coat of many colors: out-of-school figured worlds and urban girls' engagement with science. In M Varelas (Ed). *Identity construction and science education research.* (Chapter 4). Sense, Rotterdam.

Hampden-Thompson, G., Lubben, F. and Bennett, J. (2011). Post-16 physics and chemistry uptake: combining large-scale secondary analysis with in-depth qualitative methods. *International Journal of Research and Method in*

Education, 34, 289-307.

Hannover, B. and Kessels, U. (2004). Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. *Learning and Instruction*, 14, 51-67.

Haste, H. (2004). *Science in my future.* Nestle Social Research Programme, Report Number 1.

Haussler, P. and Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept and achievement in physics classes. *Journal of Research in Science Teaching*, 39, 870-888.

Hazari, Z., Sonnert, G., Sadler, P. M. and Shanahan, M-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity and physics career choice: a gender study. *Journal of Research in Science Teaching*, 47, 978-1003.

Heller, K. A. and Ziegle, A. (1996). Gender differences in mathematics and the sciences: can attributional retraining improve the performance of gifted females? *Gifted Child Quarterly*, 40, 200-210.

Hennink, M., Hutter, I. and Bailey, A. (2011). *Qualitative Research Methods.* Sage, London.

Holland, D., Lachicotte, W., Skinner, D. and Cain, C. (1998). *Identity and Agency in Cultural Worlds*. Harvard University Press, Cambridge, Massachusetts.

Holland, D. and Lave, J. (2009). Social practice and the historical production of persons. *Actio: An International Journal of Human Activity Theory*, 2, 1-15.

Holmegaard, H. T., Ulriksen, L. M. and Madsen, L. M. (2012). The process of choosing what to study: a longitudinal study of upper secondary students' identity work when choosing higher education. *Scandinavian Journal of Educational Research*, 1-20.

Holstein, J. A. and Gubrium, J. F. (1995). *The active interview.* Sage Publications.

Hughes, G. (2001). Exploring the availability of student scientist identities within curriculum discourse: an anti-essentialist approach to gender-inclusive science. *Gender and Education*, 13, 275-290.

Institute of Physics. (2010). *Engaging with Girls*. London

Institute of Physics. (2012). *It's different for girls.* London.

Institute of Physics. (2013). *Closing Doors.* London.

Jackson, P. A. and Seiler, G. (2013). Science identity trajectories of latecomers to science in college. *Journal of Research in Science Teaching*, 50, 826-857.

Jenkins, R. (2008). *Social Identity* (Third Edition). Routledge, London.

Jenkins, E. W. and Nelson, N. W. (2005). Important but not for me: students' attitudes towards secondary school science in England. *Research in Science and Technological education*, 23, 41-57.

Johnson, A., Brown, J., Carlone, H. and Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: a multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching*, 48, 339-366.

Jones, M. G., Howe, A. and Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education*, 84, 180-192.

Kaminski, D. M. (1982). Girls and mathematics and science. An annotated bibliography of British work (1970-1981). *Studies in Science Education*, 9, 81-108.

Kane, J. M. (2012a). Multiple identities and the science self: how a young African American boy positions himself in multiple worlds. In M Varelas (Ed). *Identity construction and science education research.* (Chapter 3). Sense, Rotterdam.

Kane, J. M. (2012b). Young African American children constructing academic and disciplinary identities in an urban science classroom. *Science Education*, 96, 457-487.

Kelly, A. (1988). Gender differences in teacher-pupil interactions: a meta-analytic review. *Research in Education*, 39, 1-24.

Kenway, J. and Gough, A. (1998). Gender and science education in schools: a review 'with attitude'. 1-29.

Kessels, U., Rau, M. and Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. B*ritish Journal of Educational Psychology*, 76, 761-780.

Kozoll, R. H. and Osborne, M. D. (2004). Finding meaning in science: lifeworld, identity and self. *Science Education*, 88, 157-181.

Krogh, L. B. and Thomsen, P. V. (2005). Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom. *International Journal of Science Education*, 25, 281-302.

Kvale, S. (1996). *Interviews An introduction to qualitative research interviewing.* Sage Publications.

Kvale, S. and Brinkmann, S. (2009). *Interviews* (2nd Edition). Sage Publications.

Lapadat, J. C. and Lindsey, A. C. (1999). Transcription in research and practice from standardization of technique to interpretive positioning. *Qualitative Inquiry,* 5, 64-86.

Ladubbe, P., Herzog, W., Neuenschwander, M. O., Violi, E. and Gerber, C. (2000). Girls and physics: teaching and learning strategies tested by classroom interventions in grade 11. *International Journal of Science Education*, 22, 143-157.

Lave, J. and Wenger, E. (1991). *Situated learning Legitimate peripheral participation.* Cambridge University Press, UK.

Levy, J., Brok, P. D., Wubbels, T. and Brekelmans, M. (2003). Students' perceptions of interpersonal aspects of the learning environment. *Learning Environments Research*, 6, 5-36.

Lyons, T. (2006). Different countries, same science classes: students' experiences of school science in their own words. *International Journal of Science Education*, 28, 591-613.

McAteer, M. (2000). *Contempory science education: some historical and philosophical roots.* Unpublished DPhil theses. University of Ulster.

Macnaughten, P. and Myers, G. (2007). Focus groups. In C. Seale, G. Gobo, J. F. Gubrium and D. Silverman (Eds). *Qualitative Research Practice* (Chapter 4), Sage, Los Angeles.

Manthorpe, C. A. (1982). Men's science, women's science or science? Some issues related to the study of girls' science education. *Studies in Science Education*, 9, 65-80.

Masnick, A. M., Valenti, S. S., Cox, B. D. and Osman, C. J. (2010). A multidimensional scaling analysis of students' attitudes about science careers. *International Journal of Science Education*, 32, 653-667.

Mendick, H. (2003). *Telling choices: an exploration of the gender imbalance in* *participation in advanced mathematics courses in England.* Unpublished PhD thesis, Goldsmiths College, University of London.

Mendick, H. (2006). *Masculinities in mathematics.* Open University press. England.

Meece, J. L. and Jones, M. G. (1996). Gender differences in motivation and strategy use in science: are girls rote learners? *Journal of Research in Science Teaching*, 33, 393-406.

Miller, P. H., Slawinski Blessing, J. and Schwartz, S. (2006). Gender differences in high-school students' views about science. *International Journal of Science Education*, 28, 363-381.

Mujtaba, T. and Reiss, M. J. (2012a). Factors affecting whether students in England choose to study physics once the subject is optional. NARST March 2012, Indianapolis, USA.

Mujtaba, T. and Reiss, M. J. (2012b). What sort of girls wants to study physics after the age of 16? Findings from a large-scale UK survey. *International Journal of Science Education*, 1-20.

Murphy, P. and Whitelegg, E. (2006a). *Girls in the physics classroom.* Institute of Physics, London.

Murphy, P. and Whitelegg, E. (2006b). Girls and physics: continuing barriers to 'belonging'. *Curriculum Journal*, 17, 281-305.

Olitsky, S. (2006). Structure, agency and the development of students' identities as learners. *Cultural Science Education*, 1, 745-766.

Oliver, D. G., Serovich, J. M. and Mason, T. L. (2005). Constraints and opportunities with interview transcription towards reflection in qualitative research. *Social Forces,* 84, 1273-1289.

Ong, M. (2005). Body projects of young women of color in physics: intersections of gender, race, and science. *Social Problems*, 52, 593-617.

Osborne, J. and Collins, S. (2001). Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education*, 23, 441-467.

Osborne, J., Simon, S. and Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.

Osborne, J., Simon, S. and Tytler, R. (2009). *Attitudes towards science: a* *update*. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, California.

Pawson, R. (1999). Chapter 2 in *Sociology: issues and debates* edited by Taylor, S. MacMillan, London.

Phipps, A. (2008). *Women in Science, engineering and Technology three decades of UK initiatives*. Trentham, Stoke on Trent, UK.

Pike, A. G. and Dunne, M. (2011). Student reflections on choosing to study science post-16. *Cultural Studies of Science Education*, 6, 485-500.

Price, J. F. and McNeill, K. L. (2013). Toward a lived science curriculum in intersecting figured worlds: an exploration of individual meanings in science education. *Journal of Research in Science Teaching*, 50, 501-529.

Quinn, F. and Lyons, T. (2011). High school students' perceptions of school science and science careers: a critical look at a critical issue. *Science Education International*, 22, 225-238.

Rahm, J. (2007). Youths' and scientists' authoring of and positioning within science and scientists' work. *Cultural Studies in Education*, 1, 517-544.

Rahm, J. and Gonsalves, A. (2012). "To understand the news you need science!" girls' positioning and subjectivity in and beyond a newsletter activity in and afterschool science program. In M Varelas (Ed). *Identity construction and science education research*. (Chapter 5). Sense, Rotterdam.

Rapley, T. (2007). Chapter 1 *Qualitative research practice* edited by Seale, C., Gobo, G., Gubrium, J. F. and Silverman, D. Sage Publications.

Read, B., Archer, L. and Leathwood, C. (2003). Challenging cultures? Student conceptions of 'belonging' and 'isolation' at a post-1992 university. *Studies in Higher Education*, 28, 261-277.

Reay, D. (2001). 'spice girls', 'nice girls', 'girlies', and 'tomboys': gender discourses, girls' cultures and femininities in the primary classroom. *Gender and Education*, 13, 153-166.

Reay, D., David, M.E. and Ball, S. J. (eds) (2005). *Degrees of choice: social class. Race and Gender in Higher Education*. Trentham, Stoke on Trent.

Reay, D. and Wiliam, D. (1999). 'I'll be a nothing': structure, agency and the construction of identity through assessment. *British Educational Research Journal*, 25, 343-354.

Reid, N. and Skryabina, E. A. (2002). Attitudes towards physics. *Research i*

Science and Technological Education, 20, 67-81.

Reiss, M. J. (2004). Students' attitudes towards science: a long-term perspective. *Canadian Journal of Science, Mathematics and Technology Education*, 4, 97-109.

Robson, C. (2002). *Real World Research* (2^{nd} Edition). Blackwell, Oxford.

Rodd, M., Reiss, M. and Mujtaba, T. (2012). *Undergraduates' stories about why they are studying physics: implications for policy.* ioe.ac.uk.

Rubin, B. C. (2007). Learner identity amid figured worlds: constructing (in)competence at an urban high school. *The Urban Review*, 39, 217-249.

Ryan, L. M. (2012). 'You must be very intelligent...?': gender and science subject uptake. *International Journal of Gender, Science and Technology*, 4 167-190.

Ryan, G. W. and Bernard, H. R. (2003). Techniques to identify themes. *Field Methods*, 15, 85-109.

Sawtelle, V., Brewe, E. and Kramer, L. H. (2012). Exploring the relationship between self-efficacy and retention in introductory physics. *Journal of Research in Science Teaching*, 49, 1096-1121.

Schreiber, Z. (2011). *Fizz nothing is as it seems.* Zedess Publishing.

Schreiner, C. and Sjoberg, S. (2007). Science education and young people's identity construction – two mutually incompatible projects? In D, Corrigan, J. Dillon and R. Gunstone (Eds). The Re-emergence of Values on Science Education. Sense, Rotterdam.

Schunk, D. H. and Meece, J. L. (2005). Self-efficacy development in adolescences. In F. Parjares and T. C. Urdan (Eds). *Self efficacy beliefs of adolescents (Chapter 3).* Information Age Publishing.

Schwarzer, R. and Jerusalem, M. (1979). *The general self-efficacy scale.* http://userpage.fu-berlin.de/~health/engscal.htm.

Sclater, S. D. (2007). Narrative and subjectivity. In C. Seale, G. Gobo, J. F. Gubrium and D. Silverman (Eds). *Qualitative Research Practice* (Chapter 6), Sage, Los Angeles.

Sfard, A. and Prusak, A. (2005). Telling identities: in search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher*, 34, 14-22.

Shanahan, M-C. (2009). Identity in science learning: exploring the attention given to agency and structure in studies of identity. *Studies in Science Education*, 45, 43-64.

Shanahan, M-C. and Nieswandt, M. (2011). Science student role: evidence of social structural norms specific to school science. *Journal of Research i Science Teaching*, 48, 367-395.

Sikes, P. (2010). The ethics of writing life histories and narratives in education research. In A-M. Bathmaker and P. Harnett (Eds). *Exploring learning, identity and power through life history and narrative research* (Chapter 2).Routledge, London.

Sikes, P. and Gale, K. (2006). *Narrative approaches to educational research.* Faculty of Education, University of Plymouth.

Simpkins, S. D., Davis-Kean, P. E. and Eccles, J. S. (2006). Math and science motivation: a longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42, 70-83.*

Sjaastad, J. (2011). Sources of inspiration: the role of significant persons in young people's choice of science in higher education. *International Journal of Science education*, 34, 1-22.

Spall, K., Barrett, S., Stanisstreet, M., Dickson, D. and Boyes, E. (2003). Undergraduates' views about biology and physics. *Research in Science and Technological Education*, 21, 193-208.

Spall, K., Stanisstreet, M., Dickson, D. and Boyes, E. (2004). Development of school students' constructions of biology and physics. *International Journal of Science Education*, 26, 787-803.

Squire, C., Andrews, M. and Tamboukan, M. (2008) Introduction to doing narrative research. In C. Squire, M. Andrews, and Tamboukan, M. (Eds). *What is Narrative Research?* Sage, London.

Stake, J. E. and Nickens, S. D. (2005). Adolescent girls' and boys' science peer relationships and perceptions of the possible self as scientist. *Sex Roles*, 52, 1-11.

Stewart, M. (1998). Gender issues in physics education. *Educational Research*, 40, 283-293.

Stokking, K. M. (2000). Predicting the choice of physics in secondary education. *International Journal of Science Education,* 22, 1261-1283.

Taconis, R. and Kessels, U. (2009). How choosing science depends on students' individual fit to 'science culture'. *International Journal of Science Education*, 31, 1115-1132.

Tai, R. H., Qi Liu, C., Maltese, A. V. and Fan, X. (2006). Planning early for careers in science. *Science*, 321, 1143-1144.

Tan, E. and Calabrese Barton, A. (2007). From peripheral to central, the story of Melanie's metamorphosis in an urban middle school science class, *Science Education,* 2, 1-24.

Tan, E. and Calabrese Barton, A. (2008). Unpacking science for all through the lens of identities in practice: the stories of Amelia and Ginny. *Cultural Studies of Science Education*, 3, 43-71.

Tan, E. and Calabrese Barton, A. (2009). Transforming science learning and student participation in sixth grade science: a case study of a low-income, urban, racial minority classroom. *Equity and Excellence in Education*, 43, 38-55.

Tenenbaum, H. R. and Leaper, C. (2003). Parent-child conversations about science: the socialization of gender inequities? *Developmental Psychology*, 39, 34-47.

Thomas, G. (2011). *How to do your Case Study – A Guide for Students and Researchers*. Sage, London.

Thorley, A. D. M. (2010). *Teaching influences on girls' choices to study AS-level physics*. Dissertation for MRes award at Sheffield Hallam University.

Tobin, K., Deacon, J. and Fraser, B. J. (1989). An investigation of exemplary physics teaching. *The Physics Teacher*, 3, 144-150.

Tucker-Raymond, E., Varelas, M., Pappas, C. C. and Keblawe-Shamah, N. (2012).

Young children's multimodal identity stories about being scientists. In M Varelas (Ed). *Identity construction and science education research.* (Chapter 6). Sense, Rotterdam.

UPMAP (2008). *Understanding post-16 participation in mathematics and physics*. Institute of Education London.

Usher, E. I. (2009). Sources of middle school students' self-efficacy in mathematics: a qualitative investigation. *American Educational Research Journal*, 46, 275-314.

Usher, R. (1996). Chapter 2 in *Understanding Education Research* edited by

Scott, D. and Usher, R. Routledge.

Varelas, M. Kane, J. M. and Wylie, C. D. (2011). Young African American children's representations of self, science, and school: making sense of difference. *Science Education*, 95, 824-851.

Walshaw, M. (2005). Getting political and unravelling layers of gendered mathematical identifications. *Cambridge Journal of Education*, 35, 19-34.

Watson, L. C. and Watson-Franke, M. B. (1985). *Interpreting life histories: and anthropological inquiry.* Rutgers University Press, USA.

Wenger (1998). *Communities of Practice.* Cambridge University Press, UK.

Whitehead, J. M. (1996). Sex stereotypes, gender identity and subject choice at A-level. *Educational Research*, 38, 147-190.

Wigfield, A. and Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, 25, 68-81.

Williams, C., Stanisstreet, M. Spall, K. Boyes, E. and Dickson, D. (2003). Why aren't secondary students interested in physics? *Physics Education*, 38, 324-329.

Willis, J. W. (2007). *Foundations of qualitative research interpretive and critical approaches.* Sage Publications.

Wong, B. (2012). Identifying with science : a case study of two 130year-old 'high achieving working class' British Asian girls. *International Journal of Science Education*, 34, 43-65.

Woolnough, B. (1994). Why students choose physics or reject it. *Physics Education*, 29, 368-374.

Wubbels, T. and Brekelmans, M. (1997). A comparison of student perceptions of Dutch physics teachers' interpersonal behaviour and their educational opinions in 1984 and 1993. *Journal of Research in Science Teaching*, 34, 447-466.

Wubbels, T. and Levy, J. (Eds) (1993) *Do you know what you look like?* Farmer Press, London.

Yin, R. K. (2009). *Case Study Research Design and Methods* (4^{th} Edition). Sage Publications, USA.

Zhu, Z. (2007). Learning content, physics self efficacy and female students' physics course taking. *International Education Journal*, 8, 204-212.

Appendices

Appendix 1. Year 9 Science Questionnaire

Year 9

Science Questionnaire

Name:-..

This questionnaire is part of a small research project investigating the reasons why some people study physics after GCSE and others do not.

Your teachers will not see your answers. Only Deborah (the researcher) will see your individual answers. Any results used from these questionnaires will be reported so that individual students cannot be identified.

You have been asked to write your name on the questionnaire. This is so that Deborah can identify pupils that she can invite to take part in another part of the research.

The questionnaire should only take you about 15 minutes to complete. Hopefully, you will answer all the questions, but if you don't want to answer a question you don't have to.

Section 1 Subject Choices

Q1 GCSE Choices

Which subjects have you chosen to take for GCSE next year?

....

....

....

....

....

....

Q2 Future Studies

A/ Are you intending to continue your studies after the age of 16?

YES ☐ go to C

NO/NOT SURE ☐ go to B

B/ If No/ Not sure, please explain why you are not/not sure.

Ci/ Have you considered studying Physics at AS/A'level?

YES NO

Please explain your answer.

....

....

....

....

....

....

....

Cii/ What are the subjects that you are most likely to take after your GCSEs? Please list them in order of preference with the most likely first and give a reason for your choice (e.g. interested in subject, need for future career, like teacher, friends doing same subject, anything else).

Subject	Reason

Section 2 Science at School

Q3 Science Topics

Listed below are some topics you have studied recently in science classes.

Place a tick in the box next to your favourite 3 topics.

Topic	
Global warming	
Photosynthesis	
Reactivity of metals	
Moments	
Pressure	
Selective breeding	

Which was your least favourite topic and why?

....

....

....

....

....

....

....

Q4 <u>Science Lessons</u>

Read the following statements then tick a box to indicate whether you agree, disagree or neither agree nor disagree with each statement about science at school.

	Agree	Neither agree nor disagree	Disagree
I look forward to science lessons			
In my science lessons, my teachers explain how science ideas can be applied to a number of different situations			
In my science lessons, I have the opportunity to discuss my ideas about science			
I enjoy my science lessons			
I learn new skills in science lessons			
I enjoy doing practical work in science lessons			
I like my science teachers			

Section 3.. Science Teachers

Q5 My science teachers make me more interested in science.

I agree because.......		I neither agree nor disagree because......		I disagree because.......	
	...they give us a variety of different activities to do		...how I feel about science has nothing to do with my science teacher		...they don't make it very interesting
	...they show me how what we do in science relates to the outside world				...I don't see the point in what we are doing in science
	...they are enthusiastic				...I don't understand what my science teachers say
	...they explain things clearly				
	...they make me think				
	...another reason - please say what		...another reason - please say what		...another reason - please say what

Section 4 About Physics

Q6 Below are some words that describe how I feel about physics. Circle any words that fit you and add some other words if you would like.

Enjoy Like Hate Bored

Frightened Excited Anxious

Worried Difficult Easy Interesting

....

....

....

Q7 Complete the following sentences.

a/ If I don't understand something in physics I can get help from

....

b/ If a topic in physics is hard I

....

....

Q8 Read the following statements about you and physics. Tick the ones that apply to you.

In my class, I am one of the best at physics	
In my class, I am about the same as most people at physics	
In my class, I am one of the worst at physics	
I like physics more than my friends	

I like physics about the same as my friends	
I like physics a lot less than my friends	

Q9 If you were asked to describe a physicist, what would you say?

....

....

....

....

....

....

Q10 People can be described as 'a physics sort of person'. Do you think you are a physics sort of person or not? Explain your answer.

....

....

....

....

....

....

Section 5 About You

Q11 Are you male or female?..

Q12 Where do you live?...

Q13 What is your ethnicity? Please tick one box

- White ☐
- Black ☐
- Asian ☐
- Mixed Race ☐
- Other ☐

Q14 What are your parents'/carers' occupations? Please tick one box for each parent/carer.

	Mother or Carer 1	Father or Carer 2
Professional e.g. doctor, dentist, teacher, nurse, manager		
Clerical and skilled non-manual e.g. secretary, clerk, typist, receptionist, Local Government employee (administrative/clerical)		
Senior official e.g. police, fire, prison or ambulance officer, immigration or custom officer, surveyor		
Store worker e.g. sales rep, shop worker		
Skilled manual worker e.g. plumber, electrician, fitter, chef, bus driver		
Semi-skilled manual worker e.g. hairdresser, caretaker, childcare worker		

Unskilled worker e.g. labourer, window cleaner, cleaner, bar staff		
Don't know		
Unemployed		

Thank you for completing this short questionnaire.

Would you be willing to take part in a small group interview to talk about your future subject choices and your feelings about physics and physics lessons?

YES ☐ NO ☐

Appendix 2 Year 10 Physics Questionnaire

Year 10

Physics Questionnaire

Name:-...

This questionnaire is part of a small research project investigating the reasons why some people study physics after GCSE and others do not.

Your teachers will not see your answers. Only Deborah (the researcher) will see your individual answers. Any results used from these questionnaires will be reported so that individual students cannot be identified.

You have been asked to write your name on the questionnaire. This is so that Deborah can identify pupils that she can invite to take part in another part of the research.

The questionnaire should only take you about 15 minutes to complete. Hopefully, you will answer all the questions, but if you don't want to answer a question you don't have to.

Section 1 Subject Choices

Q1 GCSE Choices

Which subjects are you taking for GCSE?

....

....

....

....

....

....

....

....

Q2 Future Studies

A/ Are you intending to continue your studies after the age of 16?

YES ☐ go to C

NO/NOT SURE ☐ go to B

B/ If No/Not sure, please explain why you are not/not sure.

Ci/ Have you considered studying Physics at AS/A'level?

YES NO

Please explain your answer.

....

....

....

....

....

....

Cii/ What are the subjects that you are most likely to take after your GCSEs? Please list them in order of preference with the most likely first and give a reason for your choice (e.g. interested in subject, need for future career, like teacher, friends doing same subject, anything else).

Subject	Reason

Section 2 Physics at School

Q3 Physics Topics

Listed below are some topics you have studied recently in physics classes.
Place a tick in the box next to your favourite 2 topics.

Topic	
Static electricity	
Electromagnetic waves	
Radioactivity	
Origins of the universe	

Which was your least favourite topic and why?

....

....

....

....

....

....

Q4 Physics Lessons

Read the following statements then tick a box to indicate whether you agree, disagree or neither agree nor disagree with each statement about physics at school.

	Agree	Neither agree nor disagree	Disagree
I look forward to physics lessons			
In my physics lessons, my teachers explains how a physics idea can be applied to a number of different situations			
In my physics lessons, I have the opportunity to discuss my ideas about physics			
I enjoy my physics lessons			
I learn new skills in physics lessons			
I enjoy doing practical work in physics lessons			
I like my physics teacher			

Section 3.. Physics Teachers

Q5 My physics teachers make me more interested in physics.

I agree because.......		I neither agree nor disagree because......		I disagree because.......	
	...they give us a variety of different activities to do		...how I feel about physics has nothing to do with my physics teacher		...they don't make it very interesting
	...they show me how what we do in physics relates to the outside world				... I don't see the point in what we are doing in physics
	...they are enthusiastic				... I don't understand what my physics teachers say
	...they explain things clearly				
	...they make me think				
	...another reason – please say what		...another reason – please say what		...another reason – please say what

Section 4 About Physics

Q6 Below are some words that describe how I feel about physics. Circle any words that fit you and add some other words if you would like.

Enjoy	Like	Hate	Bored
	Frightened	Excited	Anxious
Worried	Difficult	Easy	Interesting

....

....

....

Q7 Complete the following sentences.

a/ If I don't understand something in physics I can get help from

....

b/ If a topic in physics is hard I

....

....

Q8 Read the following statements about you and physics. Tick the ones that apply to you.

In my class, I am one of the best at physics	
In my class, I am about the same as most people at physics	
In my class, I am one of the worst at physics	
I like physics more than my friends	

I like physics about the same as my friends	
I like physics a lot less than my friends	

Q9 If you were asked to describe a physicist, what would you say?

....

....

....

....

....

....

Q10 People can be described as 'a physics sort of person'. Do you think you are a physics sort of person or not? Explain your answer.

....

....

....

....

....

....

Section 5 <u>About You</u>

Q11 Are you male or female?..

Q12 Where do you live?...

Q13 What is your ethnicity? Please tick one box

White ☐

Black ☐

Asian ☐

Mixed Race ☐

Other ☐

Q14 What are your parents'/carers' occupations? Please tick one box for each parent/carer.

	Mother or Carer 1	Father or Carer 2
Professional e.g. doctor, dentist, teacher, nurse, manager		
Clerical and skilled non-manual e.g. secretary, clerk, typist, receptionist, Local Government employee (administrative/clerical)		
Senior official e.g. police, fire, prison or ambulance officer, immigration or custom officer, surveyor		
Store worker e.g. sales rep, shop worker		
Skilled manual worker e.g. plumber, electrician, fitter, chef, bus driver		
Semi-skilled manual worker e.g. hairdresser,		

caretaker, childcare worker		
Unskilled worker e.g. labourer, window cleaner, cleaner, bar staff		
Don't know		
Unemployed		

Thank you for completing this short questionnaire.

Would you be willing to take part in a small group interview to talk about your future subject choices and your feelings about physics and physics lessons?

YES ☐ NO ☐

Appendix 3. Coding for Questionnaire (all versions)

Throughout missing answer = 99

Student ID - number on front of questionnaire

School

Balcarras = 0

Harrogate = 1

Year

Year 9 = 0

Year 10 = 1

Q2

Yes = 0

No = 1

Q2ci

Yes = 0

No = 1

Reasons
- Career = 1
- Interesting/Enjoy = 2
- Don't enjoy/Boring = 3
- Not needed for future = 4
- No reason = 5
- Not good at subject = 6
- Other = 7

Q2cii (5 entries)

Physics = 0

Chemistry = 1

Biology = 2

Maths = 3

Further maths = 4

ICT/Computing = 5

English = 6

History = 7

Geography = 8

Art = 9

Drama = 10

PE = 11

Health and Social Care = 12

Psychology = 13

Sociology = 14

Photography = 15

Politics = 16

Economics = 17

Other = 18

French = 19

German = 20

Spanish = 21

<u>Q3 (4 entries - 3 positive and 1 negative)</u>

Static electricity = 0

Electromagnetic waves = 1

Radioactivity = 2

Origins of universe = 3

Global warming = 4

Inheritance = 5

Radiation = 6

Energy transfers = 7

Habitats = 8

Photosynthesis = 9

Reactivity of metals = 10

Moments = 11

Pressure = 12

Selective breeding = 13

Q4 (7 entries)

Agree = 0

Neither agree nor disagree = 1

Disagree = 2

Q5

Agree - different activities = 0

Agree – relates to outside world = 1

Agree – enthusiastic = 2

Agree – explain clearly = 3

Agree - make me think = 4

Agree – other = 5

Agree - more than one answer = 6

Neither agree nor disagree – nothing to do with teachers = 7

Neither agree nor disagree – other = 8

Neither agree nor disagree - more than one answer = 9

Disagree – don't make it interesting = 10

Disagree – don't see point in physics =11

Disagree – don't understand teachers = 12

Disagree – other = 13

Disagree - more than one answer = 14

Confused answer = 88

Q6 (5 entries)

Enjoy = 0

Like = 1

Hate = 2

Bored = 3

Frightened = 4

Excited = 5

Anxious = 6

Worried = 7

Difficult = 8

Easy = 9

Interesting = 10

Other = 11

<u>Q7a (2 entries)</u>

Friends = 0

Teachers = 1

Book = 2

Internet = 3

Family = 4

Other = 5

<u>Q7b (2 entries)</u>

Ask friends = 0

Ask teachers = 1

Ask family = 2

Look in book = 3

Look on internet = 4

Don't do anything = 5

Think = 6

Work it out = 7

Other = 8

<u>Q8a</u>

I am one of the best = 0

I am the same = 1

I am worst = 2

<u>Q8b</u>

Like more = 0

Like same = 1

Like less = 2

<u>Q11</u>

Male = 0

Female = 1

Q13

White = 0

Black = 1

Asian = 2

Mixed race = 3

Other = 4

Q14

Professional = 0

Clerical and skilled non-manual = 1

Senior official = 2

Store worker = 3

Skilled manual = 4

Semi-skilled manual = 5

Unskilled = 6

Don't know = 7

Unemployed = 8

Appendix 4 Physics Words Word Cloud Figures

Girls who are thinking of choosing A-level physics (n=41)

Word	Number
Enjoy	8
Like	19
Hate	4
Bored	19
Frightened	1
Excited	1
Anxious	2
Worried	3
Difficult	18
Easy	6
Interesting	26
Other	12

Boys who are thinking of choosing A-level physics (n=135)

Word	Number
Enjoy	71
Like	76
Hate	5
Bored	26
Frightened	5
Excited	22
Anxious	2
Worried	1
Difficult	24
Easy	48
Interesting	106

Other	16

Girls who are not thinking of choosing A-level physics (n=158)

Word	Number
Enjoy	7
Like	27
Hate	43
Bored	104
Frightened	10
Excited	1
Anxious	12
Worried	16
Difficult	111
Easy	8
Interesting	38
Other	53

Boys who are not thinking of choosing A-level physics (n=119)

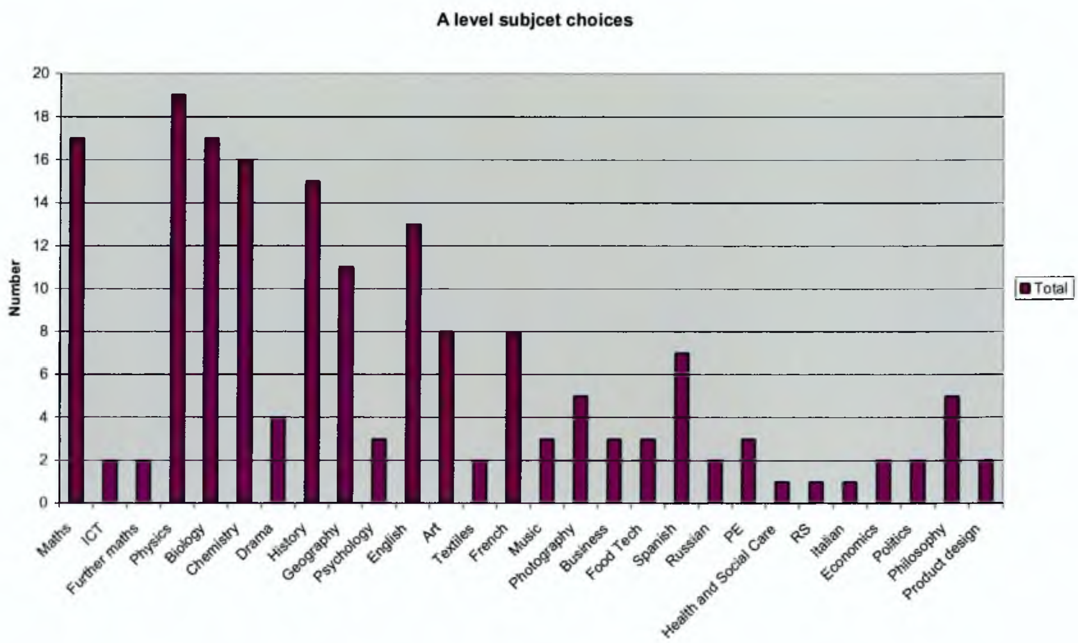
Word	Number
Enjoy	17
Like	26
Hate	21
Bored	70
Frightened	11
Excited	6
Anxious	14
Worried	16
Difficult	47
Easy	13

Interesting	42
Other	27

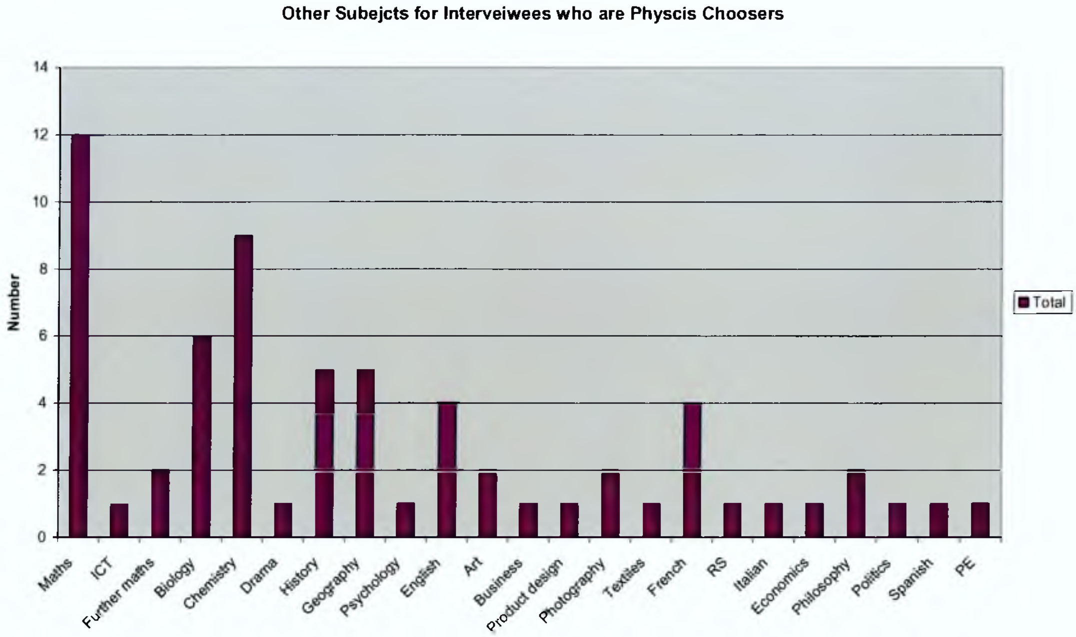
Appendix 5. Interviewees Questionnaire Responses

A-level subject choices

The girls chosen for the interviews had selected a wide range of possible subjects to study for A-level.

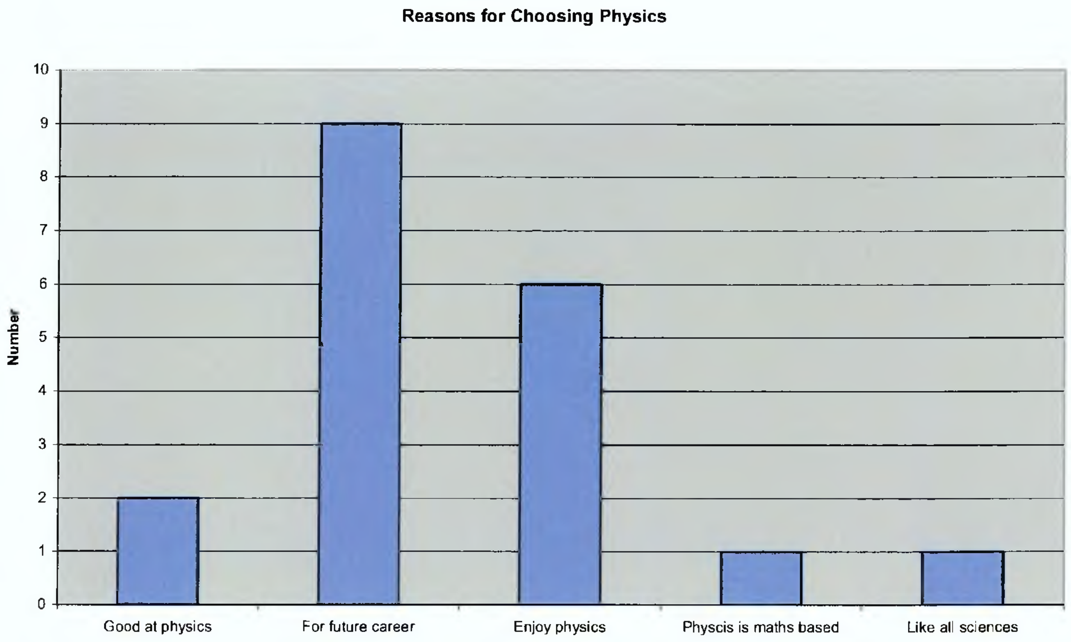


Of course, since I had selected all the girls who were going to choose physics who were willing to be interviewed for the group interviews, this chart shows a much higher than average number of girls choosing physics. I therefore investigated what subjects these physics choosers were going to choose along side physics. In my MRes research (Thorley, 2010), I had found that physics choosers could be split into two groups; those who were following a traditional science programme and those who had chosen physics in a more mixed A-level programme.

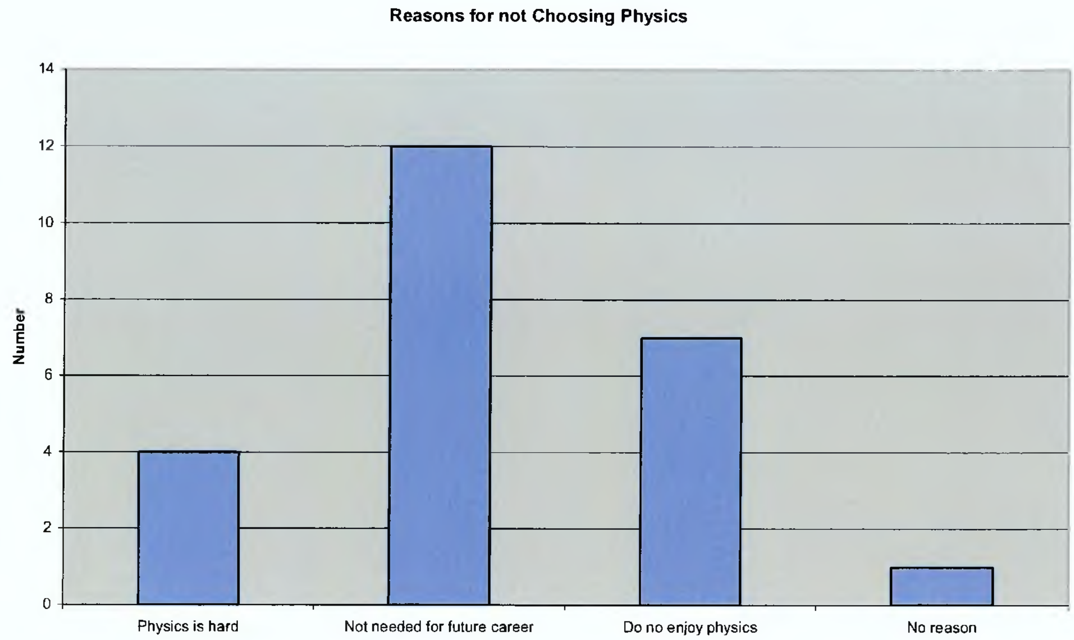


As can be seen a very wide range of other subjects were chosen to accompany physics by the 19 physics choosers selected for the group interviews. The most popular subject to accompany physics is maths with 12 girls choosing this followed by chemistry by 9, biology by 6 then history and geography with 5. However the wide range of subjects shows that physics is not only chosen as part of a mainly science A-level programme as has been traditional in the past but is included in many mixed A-level programmes. The Department of Education report (2010) looking at A-level statistics reported that for A-level science entrants, 57% took one science subject, 38% took two science subjects and just 5% took three science subjects. Of these groupings, 48% of the one science group also took mathematics, 59% of the two science group also took mathematics and 48% of the three science group also took mathematics. The report also showed that the most common subjects that were combined with mathematics and/or science at A-level were general studies, further mathematics, history and geography. These results focus on science subjects in general and do not differentiate by subject. However, it must be remembered that this subject selection is only at the proposed stage and these subjects may not actually be chosen for A-levels when the time comes.

Reasons for choosing or not choosing physics



For the 19 girls in my interview cohort who are thinking of choosing physics the main reason for doing so is linked to a future career with the second reason because they enjoy the subject. This is the same trend as for all the girls who completed the questionnaire (see chapter 5).



For those girls in the interview cohort who are not thinking of choosing physics the main reason is that they do not think that they will need physics for a future career. This again is the same as for all the girls who completed the questionnaire (see chapter 5).

For both choosers and none choosers of physics, future career aspirations are important and linked closely to future subject choices. (ref Boe et al (2012); Pike and Dunne, 2011).

Words to describe physics

Interviewees who are thinking of choosing physics

Overall as expected the most chosen word to describe physics by those girls who are going to choose physics is interesting. However, this is closely followed by bored and difficult, two words that I did not expect to feature so highly for choosers of physics.

Since I had not expected girls who were thinking of choosing physics to describe it as boring and/or difficult, I looked more closely at the girls who had chosen these words to describe physics. I looked at what other words they had chosen and the reason they gave for choosing physics to see if any other patterns emerged.

Boring	Difficult	Other words	Reason
YES	YES		Career
YES	YES		Career
YES	YES		Career
YES	YES		Career
YES	YES	Interesting	Interesting
YES	YES	Interesting	Interesting

YES		Like, interesting	Interesting
YES		Like, interesting	Maths based
YES		Like, interesting	Career
YES			Enjoy physics
YES		Interesting, hate	Like all sciences
	YES	Like, interesting	Career
	YES	Like, interesting	Enjoy physics

Of the 13 girls who had selected either or both bored and difficult as words to describe physics, six had chosen physics because of their future career. Seven of the girls had linked interesting with either bored or difficult.

Interviewees who are not thinking of choosing physics

For the none physics choosers the most common words selected to describe physics were bored and difficult followed by like and interesting. Those girls who said they liked physics or found it interesting were not choosing physics because they did not need it for a future career (6 girls); because they felt physics was hard (3 girls); because they did not enjoy it (2 girls) or they did not give a reason (1 girl).

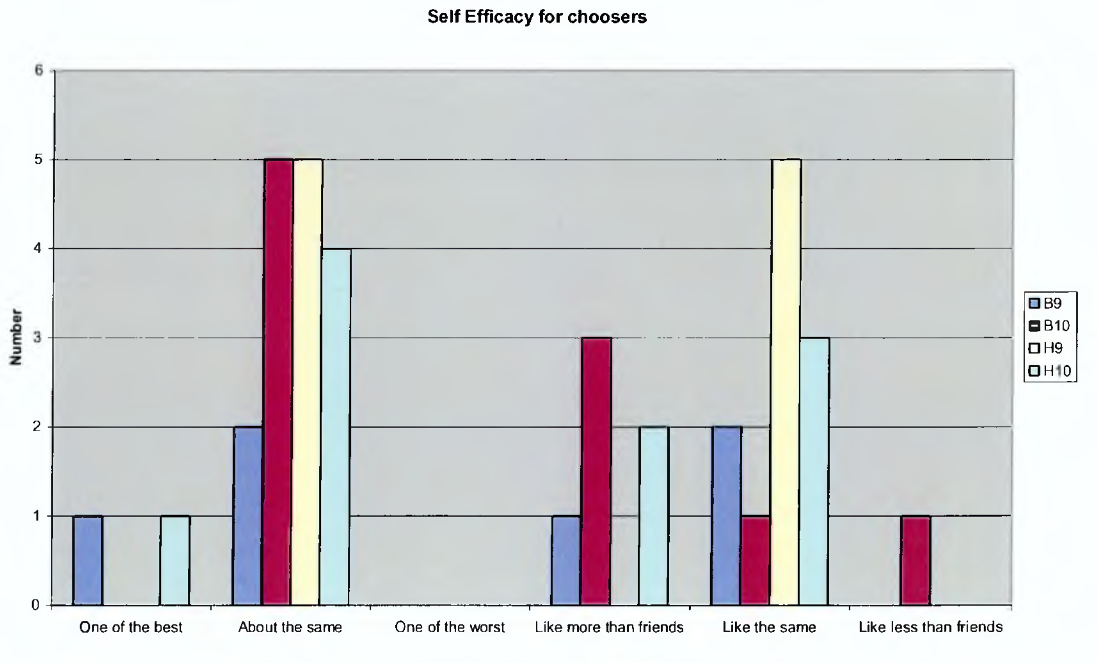
When selecting words to describe physics there are examples in both the choosers and none choosers where words that could be considered to be contradictory have been selected together and then where the overall reason for choosing physics is contradictory again.

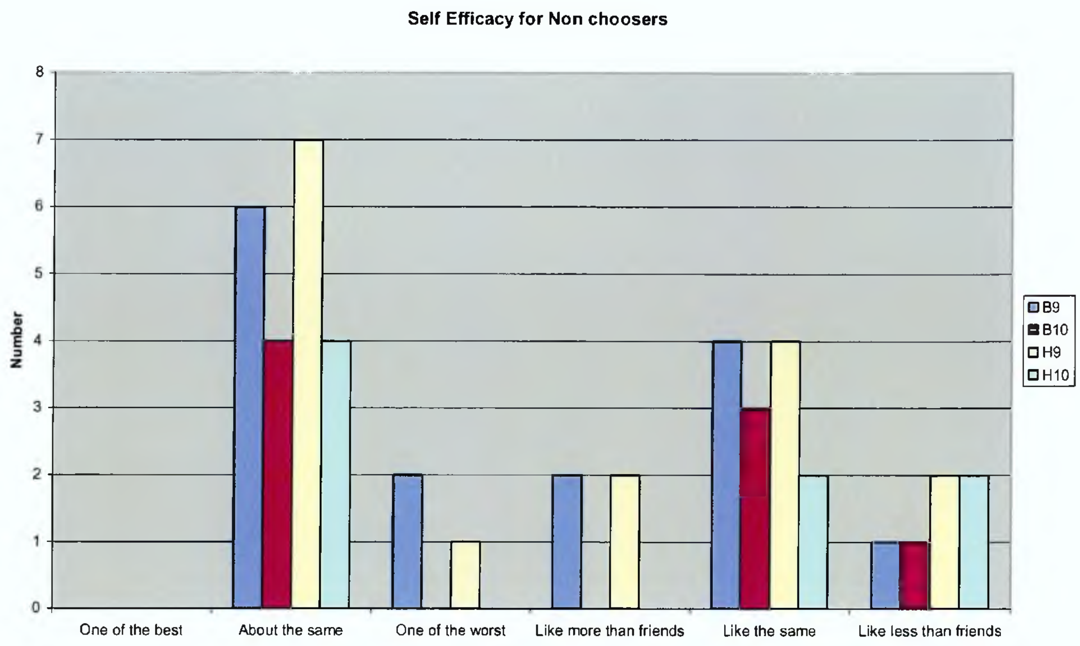
For interviewees who were either choosers or none choosers of physics, overall future career appears to be a strong influencer as to whether to choose physics or not. Six girls who were thinking of choosing physics described the subject as boring and/or difficult whereas six girls who were not thinking of choosing physics described it as interesting. Boe et al (2011), using aspects of Eccles et al

(1983) choice model, describe the unity value of STEM subjects where students will choose one of these subjects because it will help them towards their goal of a future career even if they find the subject difficult or uninteresting. However, they found that girls who chose STEM subjects in this way were especially worried about failure in that subject. Conversely, girls who found physics interesting did not think of choosing it because they did not see a link between physics and their future career. This agrees with Pike and Dunne's (2011) and Cleaves' (2005) findings where students did not choose to pursue subjects that did not fit with their future career pathways.

Physics self efficacy

As described in chapter 3, previous research has shown that self efficacy can be used as a predictor of future subject uptake (Britner and Pajares, 2006). The higher the self efficacy the more likely someone is to choose that subject.





The majority of girls selected for the group interviews report a neutral self efficacy, that is they are the same as the rest of the class for their physics ability and they like physics the same as their friends. Only two interviewees report a high self efficacy for their physics ability and they are both choosers of physics. Ten girls recorded a high self efficacy for liking physics more than their friends. Six of these girls are physics choosers but four are not. Looking at the reasons why these four girls did not choose physics three said that they did not need it for their future career and one that she found physics hard. Looking at low self efficacy three girls felt that they were one the worst in their class for physics and they were all none choosers. Seven girls said that they liked physics less than their friends and six of these were none choosers. This means that one girl who likes physics less than her friends has still chosen to take it for A-level. Her reason for this is that she needs it for her future career. This is another example of future career greatly influencing future subject choice. Therefore, from this sample, it appears that just having a high physics self efficacy with respect to liking physics more than your friends does not predict future subject choices as suggested by the work of Britner and Pajares (2006) or Porter (2011). Future career aspirations appear to have a stronger influence on choice. The same can be said for the one girl who displayed a low physics self efficacy with respect to liking physics less than her friends who would have not been predicted to choose physics by her reported self efficacy alone but who was doing so because of the value placed on it to help her enter her future chosen career.

Appendix 6. Interview Schedules

Interview 1 - overall why did they choose/not choose physics?

1/ Introductions and outline of project

2/ Let's talk about science/physics at school

What do you think of it?

Best/worst topics or aspects of science/physics lessons – do you all agree/disagree

3/ My project is all about future subject choices – what you are going to do for AS/A-level and beyond. Can you tell me about your choices and how you have decided on them? Do you all agree/disagree about the reasons for these choices?

- Prompts if needed
    - Interest of subject – what in particular
    - Ease/hardness of subject (subject kudos)
    - Parental influences
    - Peer influences
    - Teacher influences
    - Identity – i.e. who you are

4/ (For groups who have not chosen physics – if this not discussed as part of Q3)

My project is about choosing/not choosing physics. Can you talk about why you didn't choose physics? Is it the same reason/s for all of you?

5/ Is there anything else that we haven't talked about so far about future choices that you want to talk about now?

6/ Outline how project will proceed from here – are they willing to talk to me again next year

Interview 2 – physics teaching and physics teachers

1/ General intro

1. glad to see you all again
2. brief recap about what talked about in interview 1

3. intro to toady's topic

2/ Physics lessons

1. teaching and learning activities used in physics lessons (have asked them to keep notes about physics lessons in November)
    a. what type of activities have you done in physics lessons in the last month? (e.g. practical work, group work, discussions, notes, exam questions etc)
    b. which types of activities do you enjoy and why?
        i. compare with activities in favourite subject
    c. which types of activities help you learn the most and why?
        i. compare with activities in favourite subject

(can use cards of different activities to prompt if they are not sure how to describe them – e.g. may only say two or three different activities but can then ask them to look at cards and pick out any others that they have done but not actually been able to name)

3/ Your physics teacher

1. tell me about your physics teacher
    i. hoping they will describe teacher using these types of words and explain why they think so (enthusiastic, knowledgeable, strict, clever, funny etc) - could use prompt cards if not much said
2. describe how your physics teacher teaches the class/lesson – compare to favourite lesson/teacher
    i. looking for info on interactions between teachers and pupils

4/ Anything else you want to tell me about physics lessons not already covered?

Interview 3 schedule

1/ If I said to you 'what kind of person are you' how would you describe yourself and why?

2/ Now tell me about your relationship to physics.

a) How would you rate your ability in physics?

b) How does this compare to the rest of your class and your friends?
c) If you have difficulty in physics how do you deal with it?
d) How does physics make you feel?
e) Do you ever think about/ engage with physics out of school or is physics just a school subject?

3/ My project is all about girls and physics. What are your views on gender and choice?

4/ Any thing else you want to mention about girls, physics and gender issues?

Notes for next interviews:-
Interview 4 – I will probably only do some individual (1-1) or paired interviews to clarify/expand on any issues that have arisen from the first 3 group interviews. Would you be willing to participate if chosen?

Appendix 7. Girl's Interview Consent Form

The attached information sheet outlines my project - Girls' Physics Choices – A Case Study of Two Schools. Please read this carefully. If you have any questions, please ask me.

I would like you to participate in the group interview part of the research because of the answers you gave on the questionnaire. Before I can start these interviews, you need to agree to take part. Please can you answer the following questions circling YES or NO.

1/ Have you read and understood the information sheet about the project? YES NO

2/ Have you been able to ask questions about the project? YES NO

3/ Do you understand that you can stop participating at any time if you wish to without telling me why? YES NO

4/ Do you agree to let me share anonymised interview data with other researchers and use possible quotations in both unpublished and published written reports? YES NO

If you have answered YES to all the questions and want to take part in the research project, please sign below.

I agree to take part in this research project.

Name:-

Signature:-

Date:-

Appendix 8. Letter to Girls

Dear

Thank you very much for completing the questionnaire about science and physics for my research project.

The second part of my project involves small group interviews. **I would like to invite you to take part in these interviews.**

I will be in school soon to carry out the interviews. Hopefully, before the interviews, I will have time to talk to you about the research and answer any questions you have. Before then, can I ask you to read through the enclosed information sheet about my project?

I am looking forward to working with you soon.

Deborah Thorley

Appendix 9. Interview Consent

This research project is looking at the reasons why some girls choose to study physics at AS-level and others do not. I would like to ask you to participate in the interview part of this research. I would like to interview you once this year and again next year.

You have been chosen to take part in the interviews because of the answers you gave on the pupil questionnaire. These interviews will be group interviews with 2 or 3 other girls. I would like to ask you to talk about your attitude to physics and why you are thinking of choosing (or not choosing) to study physics at AS-level.

The interviews will take place at school and they should not last longer than 45 minutes. If you agree, I would like to record the interviews using a digital voice recorder so that I can transcribe the interviews for use in my research. I will be the only person who will listen to this recording and once I have finished the research the recording will be destroyed. Your identity will not be disclosed in the interview transcripts. After each interview you will have the opportunity to read and comment about the transcripts if you would like to.

The interview transcripts will be used to produce a research report. Any examples drawn directly from the interviews will be anonymous. The research report will be read by other researchers who are interested in the project and may be used for published material in the future. However, I will ensure that your identity will be protected.

If at any time during the research process you change your mind and want to stop participating, then you can do so without having to give a reason. If at any time during the interviews you are not happy to answer a question that is not a problem.

I hope that you would like to participate in this research. If you have any further questions, please feel free to ask me.

I……………………………………am willing to participate in this research project. I understand that any information given in the interviews and used in the research report and in any future published material will be done in such a way that I cannot be identified.

Signed……………………………………………

Date………………………………………………

I………………………………parent/guardian of the above named agree that she can take part in this research project and that any information given will remain private and anonymous.

Signed…………………………………………….

Date……………………………………………….

Appendix 10. Letter to Schools

Centre for Science Education
Sheffield Hallam University
Howard Street
Sheffield
S1 1WB
a.thorley171@btinternet.com

Head's Name
School address1
School address2
School address 3
School address 4

Date

Dear name

I am a doctoral researcher at Sheffield Hallam University. My research is focused on girls' progression to AS Physics. I am writing to you to ask if your school would be interested in taking part in this research. The percentage of girls taking AS Physics is still only about 20% of the total and the aim of this research is to contribute to knowledge to find ways to increase this participation rate.

My main research activity will involve talking to small groups of girls about their attitudes to physics and their GCSE and future AS subject choices. Ideally, I should like to interview a selection of girls from Yr 9 and 10 this school year and then interview the same groups of girls again in 2011/12. In order to help me choose which girls to invite to participate in the interviews I would initially carry out a short, 10 minute, survey with one or two classes in each year group. To understand more about the pupil's responses, I should also like to spend some time observing the pupil's physics lessons and talking to their physics teachers. If you agree to take part, I will, of course, minimise any disruption to normal lessons. Summaries of my findings would be made available to the school to help inform planning.

If you feel that this might be a project in which would be interested I would very much welcome the chance to come and talk to you and your physics colleagues about my proposed research. At this short meeting I would be able to give you more details about the project, discuss how many days I would like to visit the school (I would suggest eight days in total for this academic year; three in the Spring term and five in the Summer term and up to 15 days next academic year spread over the year) and discuss how the outcomes could be of benefit to your school. Following this initial meeting I would then provide further information about consent and ethics procedures for this research.

If you feel this is a project in which your school would be interested, please contact me using the above e mail.

Appendix 11. Project Information for Schools

Girls' Physics Choices – A Case Study of Two Schools

This research project is being undertaken by Deborah Thorley of Sheffield Hallam University. I can be contacted by e mail at a.thorley171@btinternet.com.

This research project is looking at the reasons why some girls choose to study physics at AS-level and others do not. There will be three parts to the research. The first will be a questionnaire given to all pupils in year 9 and 10 who are expected to achieve at least a grade B for GCSE Science or Physics. Using the answers to these questionnaires, girls will be selected for small group interviews. Girls will be selected who have expressed an interest in taking physics at AS/A-level and those who have not. Interviews with the girls will take place over two academic years, about one interview per term. More interviews may be included if follow up sessions to clarify data are needed. The final part of the research will be lesson observations of year 9 and 10 physics classes and discussions with the teachers.

The questionnaire will take about 15 minutes to complete. It will ask the pupils questions about which GCSEs they have chosen/are taking and which AS levels or other post 16 qualifications they are thinking of taking. It will also ask some general questions about thoughts about science and physics at school.

The interviews will be group interviews with 3, 4 or 5 girls. I would like to ask them to talk about their attitude to physics and why they are thinking of choosing (or not choosing) to study physics at AS-level.

The interviews will take place at school and they should not last longer than 45 minutes. If the girls all agree, I would like to record the interviews using a digital voice recorder so that I can transcribe the interviews for use in my research. I will be the only person who will listen to this recording. The identity of individuals will not be disclosed in the interview transcripts. After each interview

there will be the opportunity for the girls to read and comment about the transcripts if they would like to.
The lesson observations and discussions with teachers will be used to support the information given by the girls in their interviews. The lesson observations will be focusing on how the girls interact with each other, other pupils and the teacher. Discussions with the teachers will investigate their general feelings about physics teaching. After each observation and discussion there will be an opportunity for the teacher to comment on my notes.

The questionnaire, interview transcripts, lesson observation notes and teacher discussions will be used to produce a research report. Any examples drawn directly from the data will be anonymous. The research report will be read by other researchers who are interested in the project and may be used for published material in the future. However, I will ensure that all identities will be protected.

If at any time during the research process any of the participants change their mind and want to stop participating, then they can do so without having to give a reason.

I hope that you would like to participate in this research. If you have any further questions, please feel free to ask me.

My director of studies at Sheffield Hallam University is Dr Mark Boylan. If you would like to discuss any aspect of this research with him he can be contacted at Department of Teacher Education, Sheffield Hallam University, Howard Street, Sheffield, S1 1WB, 0114 2256012 m.s.boylan@shu.ac.uk

Appendix 12. Teacher Consent Form

The attached information sheet outlines my project - Girls' Physics Choices – A Case Study of Two Schools.

The third part of the research project involves lesson observations and teacher discussions. I would like to ask you to allow me to observe some of your year 9 and 10 lessons over 2 years and also to talk to you about physics teaching in general. If you are willing to be involved in this project, please can I ask you to complete the form below?

Please answer the following questions with YES or NO.

1/ Have you read and understood the information sheet about the project?

2/ Have you been able to ask questions about the project?

3/ Do you understand that you can stop participating at any time if you wish to without telling me why?

4/ Do you agree to let me share anonymised lesson observation and discussion data with other researchers?

If you have answered YES to all the questions and are willing to take part in the research project, please sign below.

I agree to take part in this research project.

Name:-

Signature:-

Date:-

Coding for Interview Data.

A/ From interview questions.

Yes to choose physics
- respondents have indicated that they are going to choose physics for A-level
  - interest
  - needed for future career
  - best science subject
    - reasons given for choosing physics

No to choose physics
- respondents indicate that they are not going to choo[se] physics for A-level
  - boring or not interesting
  - not needed for future
  - too hard
    - reasons given for not choosing physics

Influences on choices
- what/who has influenced their choices for A-level.
  - parent
    - positive encouragement to choose certain subje[cts]
    - encourage to choose what I want
    - no impact
      - influences of parents
      - possible influences that parents can have
  - other family
    - similar choices to family
    - opposite of family
      - brothers/sisters/wider family influ[ence]
  - peers

- do same as
- not affected by them
  - influence of peers on choices
- teachers
  - teachers encourage me to choose their subject
  - don't like teachers
  - like teachers
    - how teachers can influence choices by encouraging or just by relationship with student.

Subjects / topics like in physics
- subjects/topics respondents indicate that they like in physics
  - astrophysics

Subjects / topics don't like in physics
- Subjects/topics respondents indicate as not liking in p
  - electricity
  - equations

Relationship of physics to maths
- comments made about how physics is related to mat
  - like link
  - don't like link
    - how link of physics to maths is liked / not like and so effects on overall interest in physics.

Activities done in recent physics lessons
- questions asked directly about whats done in recent physics lessons
  - activities enjoyed
  - activities did not like

Activities that you enjoy in any lesson
- activities identified as being enjoyable in any subject lesson

Activities that help you learn in any lesson
- activities identified as helping learning in any subject

Activities that don't like or help you learn in any lesson
- activities identified as disliking or boring or not helpful to further learning gained in any subject.

Physics teachers
- comments specifically made about physics teachers

Physics teaching
- comments specifically made about physics teaching

(both above include good and bad comments)

Best teacher traits
- comments made about good teachers - all subjects other than physics specific

Best teaching traits
- comments made about good teaching - all subjects other than physics specific.

What kind of person are you?
- comments made in response to directly posed question

Scored ability for physics 1-10

Physics ability compared to class
- how respondents feel their ability in physics compares to the rest of their class

Physics ability compared to friends
- how respondents feel their ability in physics compares to their friends.

Difficulty in physics
- if respondents have a problem in physics who do they ask for help and why
  - ask teacher
  - ask friends
  - ask family
  - use books

Physics feelings
- how does physics make you feel.

Physics outside of school
- encounters with physics outside of school.

Physics - relationship of school to outside
- does physics inside / taught at school have a relationship to physics in the world in general
  - does exist
  - not the same

Gender and choices
- responses to directly asked question about how gender could influence choices

B/ From interview data.

Topics like in physics
- More topics that respondents like in physics
    - energy
    - electricity
    - electromagnetic waves
    - experiments in general

Topics don't like in physics
- More topics that respondents don't like in physics
    - energy

No to choosing physics.
- least favourite science
    - another reason for not choosing physics A-level

Descriptions of a physicist
- a question asked on questionnaire and re-answered in interviews

Attitudes of others to you doing physics
- friends
- family
    - if respondent choosing physics, comments made to by others about this choice!

Physics has right answers
- comments made about physics having the right answers, fixed answers and not being a creative subject that allows for discussion and comment.

Subjects as gifts or not
- comments made about some subjects only being able to c
as have natural ability or gift whereas others can be work

Poor teaching traits
- comments made about poor/bad teachers and teachers
in any subject - not specific to physics.

Influences on choices
- Specialism of teacher
- how perceived/known specialising teacher,
especially in science, can influence choice

Pressure to do well
- comments about pressure on pupils to do well/succeed
subjects, from teachers/parents

Self efficacy and feedback
- comments made about how feedback from teachers
can affect pupils self efficacy/feelings about a subject
- impact of feedback generally

Ability compared to class and setting
- ability in subject (not physics) compared to rest of class a
how setting by ability affects pupils.

Influences on choices
- grades
- how grade in subject can influence choice
- lack of job knowledge
- how knowledge, or lack of, about future jobs can

Ideal physics lesson
- responses to directly asked question about what to include in an ideal physics lesson

Class dynamics
- how class dynamics (behaviour etc) affects enjoyment of subjects.

Physics problem
- no: teacher
- do nothing
- what do you do if you have a physics problem

Physics as masculine subject
- discussions about physics being a masculine subject or not and other subjects as well.

Society and gender
- comments about how society perceives gender

Boys and physics
- comments that boys are better at physics than girls

Physics is hard
- discourse of physics as a hard subject

Appendix 14. Research Schedule

	Date	Activity	Interview Themes
1	May 2011	Questionnaire	
2	June 2011	Interview 1 (Group) Year 9 or 10	Choices and reasons for choices
3	Nov/Dec 2011	Interview 2 (Group) Year9 now 10; Year 10 now 11 Lesson Observations – Browning school	Physics teachers and physics teaching
4	End March/June 2012	Interview 3 (Group) and lesson observations (Browning school)	Physics self efficacy and identity.
6	Jan 2013	Interview 4 (Individual)	In depth discussion on identity and self efficacy