A STUDY INTO THE PARTICIPATION AND ENGAGEMENT OF YOUNG PEOPLE WITH PHYSICS IN POST-COMPULSORY EDUCATION

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A doctoral report submitted in partial fulfilment of the requirements of the University of Sunderland for the degree of Professional Doctorate

October 2012

Abstract

This report, submitted in conjunction with the portfolio, presents an investigation into the participation and engagement of young people with physics in post-compulsory education. This study explores the reasons why we must encourage more young people to study physics, as it is a challenging yet rewarding discipline that can lead to a wide variety of employment opportunities. The study also considers how we can encourage more young people to study physics, including factors inside and outside of the classroom.

The portfolio consists of ten separate reports, each addressing a different aspect of the study. The study is of a mixed methods design, employing a range of qualitative and quantitative data, as well as two action research projects. As a professional doctorate study, it is based largely upon my professional practice as a teacher and manager at a large college of further education. Whilst the college is based in the north east of England, my findings are not confined to this geographical region, but extend across the UK.

The study shows that after considerable interventions and initiatives, the number of GCSE candidates in physics has increased over the past ten years, with the gender balance being almost equal. Within post-compulsory education, the situation is very different, as the number of young people who study physics at A level and university is far less than we need to fill the 'skills gap' in the UK. The gender issue becomes far more prominent at each stage of the educational ladder. It was found that whilst the teacher can have a profound influence upon students' enjoyment of a subject, external factors such as parents, educational establishment, role models and the media can all influence the decisions made by young people in post-compulsory education. These factors are investigated within this study. One of the main findings was that physics, as an academic subject, is thriving in the independent sector and prestigious universities, and is arguably becoming an 'elite' subject.

The report concludes with a series of recommendations for teachers, educational establishments and external organisations, which are aimed at increasing the numbers of young people who progress to study physics in post-compulsory education. Some of the suggestions include increasing the number of specialist physics teachers (particularly female physics teachers) and improving the inter-personal skills of physics teachers. The report also suggests that due to the current status of teachers in further education, it is difficult to attract and retain good physics teachers when there are many other financially rewarding careers available for physics graduates.

Contents

List of Charts and Tables

Acknowledgements

I am indebted to my supervisors Dr. Judith Kuit and Dr. John Fulton for their invaluable guidance, support and inspiration. I would also like to thank my former supervisor, Professor Caroline Walker-Gleaves as well as the programme leader, Professor Peter Smith, who have also shown tremendous enthusiasm and encouragement.

I would like to thank the management of Sunderland College for their support in this study, with particular gratitude for the advice, guidance and contributions from Dr. William Hodgson, Merv Stapleton, Joanne Roulstone, Patricia Jakeway, Alf Bennett, Dr. Stephen Bowlzer and Dr. Chris Wagstaffe, all of whom I would like to thank wholeheartedly. I would also like to thank Dave Duell who provided the initial encouragement and opportunity to study for the professional doctorate.

My studies have relied upon extensive collaboration with external agencies, particularly the Institute of Physics, STEMNET, WISE, the Science Learning Centre (Durham) and Connexions. The professionals from these external organisations who have kindly helped with my studies are Dr. Ruth Wiltsher, Dr. Michael Johnson, Dr. Carol Davenport, Mike Cole, David Rogers, Andrea Fairless and Andrew Carton.

I would like to thank all of the teachers in my team at Sunderland College (Science, Mathematics and Psychology) for their support, good humour and hard work, as well as all of the students that I have had the pleasure of teaching and without whom this study would not have been possible. Finally, I would like to thank my family for all their encouragement, patience and understanding.

Chapter 1 Introduction

1.1 Background to the study

As a practising physics teacher with many years experience, I have gained considerable satisfaction from sharing my enthusiasm for my subject with young people. As the Curriculum Leader for Science and Mathematics at a large college of Further Education, I have been perplexed by the gradual decrease in the number of students who have chosen to study physics at the college, as well as the number of students who choose to study this subject at university. Whilst JCQ (Joint Council for Qualifications) figures indicate that the numbers of physics students at GCSE and A level are increasing nationally (JCQ, 2010), the numbers for the city in which this study is based are not as encouraging.

Physics, as an academic discipline, can be a challenging yet very rewarding subject which can develop a wide range of transferable skills. Whether studied at GCSE, A level or university, physics can lead to a variety of career opportunities which can extend beyond science to wider professions such as finance, business and management. Particularly at a time of economic recession, the study of physics is a useful qualification at any level of education.

Government reports acknowledge that there is a national skills shortage of scientists and that it may be necessary to recruit scientists from abroad in order to fill vacancies. ‘Taking Stock: the CBI Education and Skills Survey’ (CBI, 2008) claimed that 59% of companies that employ graduates of STEM (Science, Technology, Engineering and Mathematics) subjects are experiencing difficulties with the recruitment of qualified staff and that some of the larger firms may have to recruit internationally. The companies that participated in the survey recognised that STEM graduates have a wide range of transferable skills that can be applied to many professions.

1.2 The aims of the research

Within the scope of my current position, I have the opportunity to reflect upon my professional practice and consider ways in which I can improve as a teacher. Whilst the 'success' of a teacher or an educational establishment is generally measured by examination results, education in its widest sense extends beyond this to include the wider passion, engagement and enthusiasm for learning. At the college where I am employed (which for the purpose of this study shall be referred to as the FEC), we have held 100% pass (achievement) rate in A level physics for the past seven years (2005 to 2011 inclusive), yet we are always striving towards improving our teaching.

When the possibility of participating in a professional doctorate programme was suggested by a senior manager at the college, I welcomed this as an opportunity to formalise some of the work I had conducted into various aspects of my professional practice. As a female physics teacher, I have held a particular interest in exploring gender differences and had conducted a range of informal investigations into how girls' and boys' perceptions of the subject differed. This is a very important issue, but the main concerns for this study are the wider issues of physics in post-compulsory education.

Since the National Curriculum was introduced in 1988, the study of science is compulsory for all young people up to GCSE. JCQ data show that the number of candidates for GCSE physics is increasing, with girls constituting 44% of the cohort (JCQ, 2010). Physics is the least popular of the three A level science subjects, yet can lead to a wide variety of university courses and careers. Therefore one of my concerns is the progression of young people from GCSE to A level physics.

For those students who have chosen to study A level physics, it is important to ensure that we provide inspiration for our students, not only to achieve the best grades possible, but to foster a love for learning that can extend beyond the confines of the classroom. Over the years, I have developed a range of strategies to engage students in the study of physics that have, in my opinion, contributed significantly towards excellent achievement rates. Despite our students achieving success at A level and enjoying the subject, very few choose to study physics at university, with only one girl from the FEC choosing to study physics in the past ten years. Therefore the issue of why young people are not choosing to study physics, with girls as a disproportionately large subset, is of particular concern and this study will aim to explore the reasons for these decisions.

Some of the factors that influence the decisions made by young people extend beyond the powers of a teacher. Some of these external factors include parents and peers (Hattie, 2003), role models and the media (Kitzinger, 2008), as well as social class (Reay et al., 2001). This study will consider the factors both inside and outside of the classroom in order to contextualise the problem.

Over the past ten years, many of my students have expressed an interest in studying physics at university. Within the north east of England, there is only one university that offers physics undergraduate degree programmes, however, the entry requirements for this prestigious university are particularly high. If students are unable to achieve the outstanding grades necessary for this university, they are denied the opportunity of studying for a degree in physics in the north east of England. As a widening participation college, with the majority of our students having no family experience of university, the main consideration is whether a degree course can be studied in this area (88% of students from the FEC selected local courses for Higher Education in 2011).

Whilst this particular study is located within the north east of England, many of the findings can be applied to other areas of the country. The problems with students' written communication in physics A level examinations is a national problem (OCR Examiner's Report, 2008, p.21), as well as the fact that many students are choosing to study other subjects if physics is not offered locally. The National Network Co-ordinator at the Institute of Physics refers to this problem as the 'physics deserts'. In an email in 2009, he states: 'Given that many students now go to universities within 50 miles of their home, this is a real problem' (Williams, 2009).

The aim of this research is:

To investigate the participation and engagement of young people with the study of physics in post-compulsory education.

The main objectives are:

1) To explore the current levels of participation in post-compulsory physics education and consider why it is important to increase the number of young people who study physics.

2) To look at different strategies for engaging students with the study of physics in post-compulsory education and determine the impact that teachers can make on this engagement.

Key Research Questions:

1) What is the current situation with the study of physics in post-compulsory education?

2) To what extent is there a gender imbalance within physics?

3) Can teaching and learning strategies in the classroom encourage more young people to study physics?

4) Can the performance of students in A level physics modular examinations reveal any key differences between how boys and girls learn physics?

5) To what extent does subject choice depend upon wider social, cultural and economic factors?

1.3 Structure of the report and the portfolio

This study combines theoretical aspects of educational research with practical classroom-based activities. As a practising physics lecturer, I have drawn upon my own experiences and initiatives as well as seeking the support and co-operation from AS and A2 physics students, colleagues and support staff at the FEC where I am employed.

Within the classroom, teaching can be evaluated qualitatively by involving the students directly with surveys, interviews and group discussions. The impact of teaching strategies can be measured quantitatively by the examination results. Through a detailed analysis of the performance of students in the different examinations, this study will determine whether there are any gender imbalances between the different modules.

The research utilised a wide range of empirical data obtained from the FEC, which included statistical information, case studies, interviews and student surveys. External organisations that have provided information for this study include Connexions and the Local Authority. Further information has been obtained from official sources such as the UCAS statistical data website and the Prospects website. There have also been personal communications with staff from local universities.

1.3.1 The Report

Chapter 1: **Introduction**

This chapter will contextualise the research and outline the aims, objectives and key research questions. It will explain the unique contribution that this report and portfolio can make to the profession.

Chapter 2: Reflections upon a Career in Teaching

This chapter presents an autobiographical discussion, outlining some of the main influences and experiences that have shaped my career and reflections upon what I have learned.

Chapter 3: **Literature Review**

This chapter will present a discussion of previous research that has been conducted into this subject, reviewing the extent of the literature that has already been published.

Chapter 4: Research Design and Methodology

This chapter will outline the overall methodology used throughout the studies contained within the portfolio.

Chapter 5: **Findings from the Research**

This chapter will summarise the key findings from each of the sections within the portfolio, in the context of the key research questions.

Chapter 6: **Recommendations and Conclusions**

This chapter will outline the main conclusions that can be drawn from the sections within the portfolio and how they can make a unique contribution towards the profession.

1.3.2 The Portfolio

The portfolio submitted in support of this study contains the following sections:

1) Progression from GCSE to A level Physics
2) The Progression of A level Students into Physics Degree Courses
3) Teaching and Learning within the Physics Classroom
4) An analysis of student Performance in A level Physics Modular Examinations
5) Physics Action Research Project
6) Encouraging young people to study science: External Initiatives

7) Physics Education: Influences Outside of the Classroom

8) Analysis of UCAS Destinations

9) Where can Science lead you?: Careers in Science

10) Women in Physics

11) Additional information in support of this study

For each of the studies within the portfolio, I have actively sought evaluations and constructive criticism from professionals within the college, as well as evaluations from consultants representing external organisations. Chart 1.1 (page 9) indicates where the main objectives are related to the sections within the portfolio. Chart 1.2 (page 10) relates the key research questions to the sections within the portfolio.

Chart 1.1

The Main Objectives

1) To explore the current levels of participation in post-compulsory physics education and consider why it is important to increase the number of young people who study physics.

→ Sections 1 and 2

2) To look at different strategies for engaging students with the study of physics in post-compulsory education and determine the impact that teachers can make on this engagement.

→ Sections 3 to 10

Chart 1.2

Key Research Questions

Sections 1 and 2	1) What is the current situation with the study of physics in post-compulsory education?
Sections 1 and 2	2) To what extent is there a gender imbalance within physics?
Sections 3, 5 and 6	3) Can teaching and learning strategies in the classroom encourage more young people to study physics?
Section 4	4) Can the performance of students in A level physics modular examinations reveal any key differences between how boys and girls learn physics?
Sections 7, 8, 9 and 10	5) To what extent does subject choice depend upon wider social, cultural and economic factors?

1.4 The contribution of this study

In order to address potential skills shortages in the future, we need to increase the number of students who study A level physics and then progress to university. As well as the practical aspect of needing more scientists, there is also the simple fact that A level physics provides a rigorous and challenging discipline that enhances one's general education. The study of physics can develop transferable skills that can be applied to a wide range of careers, not necessarily confined to science. The PROSPECTS website claims:

> 'Physics courses also allow you to develop numerous transferable skills that are valued by employers. Many employers are attracted to recruiting physics graduates because they have a good mix of technical skills, such as a high level of numeracy and mathematical modelling, together with research-related skills and good problem-solving and analytical skills, including data analysis and critical appraisal.'
>
> (PROSPECTS, 2011)

The Institute of Physics produce a guide for the university accreditation of physics degrees, which clearly states that physics degrees should develop transferable skills (The Physics Degree, IOP, 2010).

Whilst a purely academic study might lead to a greater understanding of the issues, this professional doctorate study will suggest strategies to address the situation that can be applied within the context of professional practice. Exploring the reasons why young people choose particular subjects will provide an insight into the influences that shape the decisions made by young people. Addressing the gender imbalance, the research will also investigate the factors that influence the decisions made by girls.

Each of the ten main sections within the portfolio explores a particular aspect of physics education, ranging from teaching and learning within the classroom to the wider issues that shape subject choice outside of the classroom. Drawing upon empirical data, interviews and experience from the FEC, the study will be largely focused upon exploring the factors that are involved within this particular geographical area, with the practical aim of increasing the number of students who study physics at the FEC, as well as increasing the number of students who choose physics-related degree courses at university. It must be stated, however, that whilst the study is based in the north east, many of the findings can be applied throughout the United Kingdom.

Whilst preparing for the professional doctorate programme, a literature review was conducted to establish previous research that had already been conducted into physics education. A discussion of this research is presented in Chapter 3, although it was immediately apparent that the majority of the research had been conducted with secondary school pupils, with very little research into the post-compulsory age range. Working at a large college (FEC) presented a unique opportunity to contribute towards the debate, as being the main provider of post-16 education within the city, it has a greater number of students than smaller school sixth forms. On the issue of gender and physics, the Institute of Physics report ‘Girls in the Physics Classroom’ states:

> ‘There is limited recent research into gender and physics, particularly in England. It was therefore felt that the absence of research evidence was as important as its presence.’
>
> (Murphy and Whitelegg, 2006, p.v)

Table 1.3 (page 14) presents a chronological ‘timeline’ of the production of each section contained within the portfolio. Table 1.4 (page 15) shows a more schematic representation of how the study progressed, with Sections 1 and 2 framing the study by exploring the current situation with physics education.

The original research proposal (2008) planned to investigate issues inside the classroom (Sections 3 and 4) and outside of the classroom (Sections 6, 7, 8 and 9). The action research project (Section 5) was not part of the original proposal, but is a consequence of my concerns with developing communication skills with students. Whilst conducting research, I discovered that the Science Learning Centres offered opportunities for physics teachers to participate in structured action research projects. This was particularly useful as it provided funding, regular training and supervision, as well as the outstanding support and encouragement of the facilitators.

Similarly, Section 10 arose as a consequence of my investigations into why girls were not choosing to study physics. Although I had not planned these interviews in the original research proposal, as the study progressed it became increasingly necessary to explore the reasons that attracted some women to study this subject and identify any common themes which emerged.

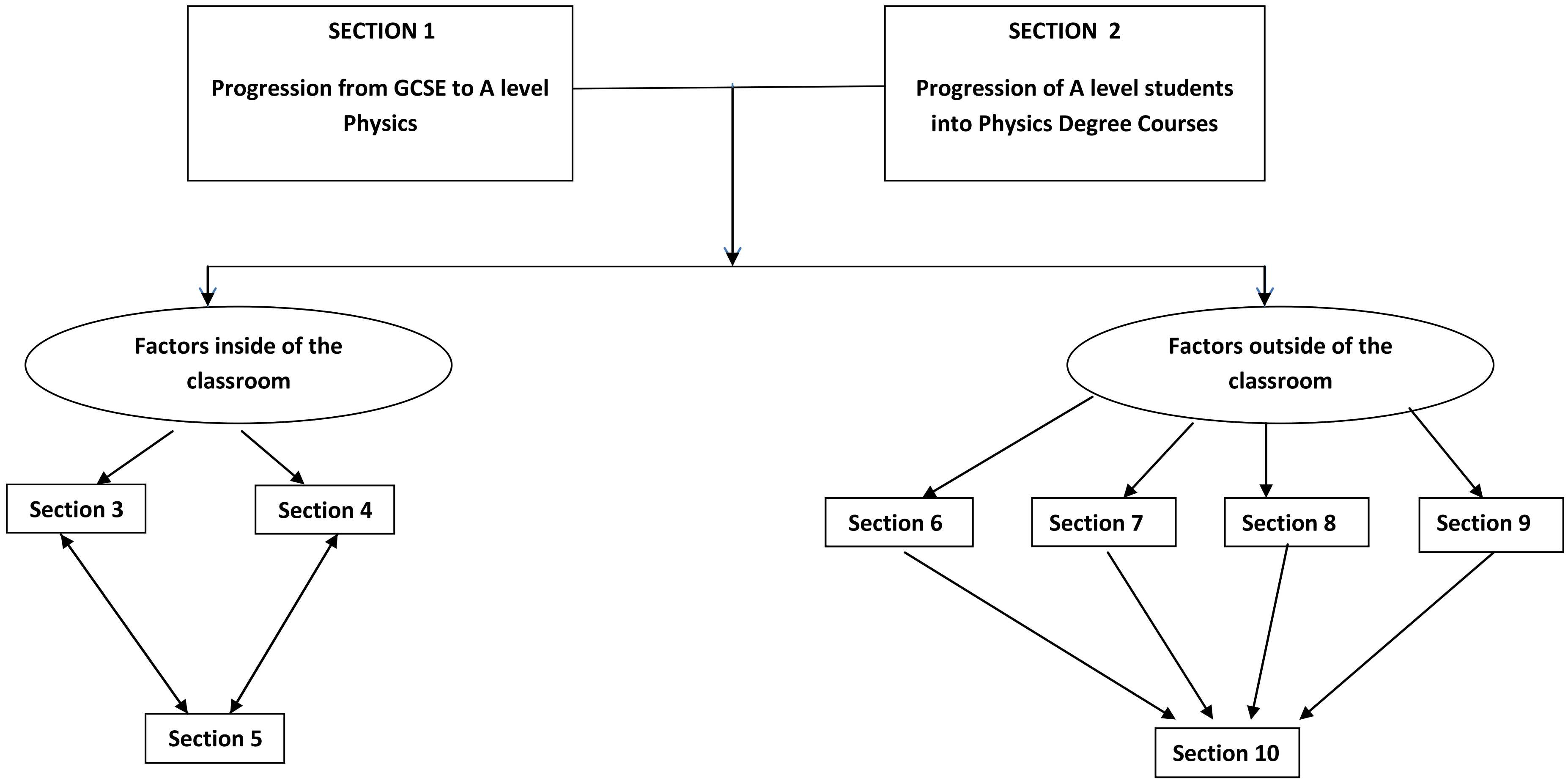
TABLE 1.3

Timelines of Sections

DATE	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
APRIL to JUNE 2008	Began study	Began study	Participated in Project Think!							
JULY/AUGUST 2008	Research into progression from GCSE to A level physics	Research into progression from A level to degree study		Analysed Examination Data 2008						
SEPTEMBER TO DECEMBER 2008	Produced draft report	Produced draft report		First report on Examination Performance				Analysed UCAS Progression Data 2008		
JANUARY TO JUNE 2009			Research into teaching and learning issues				Questionnaire with students/parental involvement	Produced draft report		
JULY/AUGUST 2009			Produced draft report	Analysed Examination Data 2009	Applied to SLC to participate in project.		Research into educational establishments			
SEPTEMBER TO DECEMBER 2009			Completed report	Second report on Examination Performance	Started Action Research Project. (1st training session)	Started report	Research into role models and the influence of the media	Analysed UCAS Progression Data 2009		
JANUARY TO JUNE 2010					(2nd and 3rd training sessions) Presentations at SLC	Research into external initiatives	Produced draft report	Updated and completed report	Meetings with Connexions Advisors	
JULY/AUGUST 201O				Analysed Examination Data 2010	Produced draft report	Produced draft report			Produced draft report	
SEPTEMBER TO DECEMBER 2010	Updated and completed report	Updated and completed report		Third report on Examination Performance	Completed Report using examination and progression data.	Updated and completed report			Completed report	Case Studies
JANUARY TO JUNE 2011				Combined separate reports into one report.			Updated and completed report			Produced draft report
JULY TO DECEMBER 2011										Completed report

TABLE 1.4

Schematic Diagram of Sections



After completing the first two reports (Sections 1 and 2 within the portfolio), which outline the problems in attracting young people to study physics at both A level and at university, these studies were shared with the Institute of Physics. This led to a strong partnership with the Institute of Physics (Stimulating Physics) Consultant for this region and we have subsequently worked together to explore methods of engaging young people with physics.

The study which explored teaching and learning strategies within the classroom (Section 3 of the portfolio) was initiated after taking part in a cross college project to develop resources into Higher Order Thinking Skills. Working with a range of teachers from other disciplines can be more creative and inspirational than working with teachers from your own subject discipline. The sharing of good practice across disciplines as well as the integration of practical knowledge was recognised by Jarvis as one of the future developments of professional practice (Jarvis, 2002, p.238).

The resources generated from this project were shared with other departments, as well as the teaching and learning coaches at the FEC. One of the common themes which emerged from this project was the importance of developing good written communication skills with A level students. All of the A level teachers who participated in the project expressed concern that students were achieving strong GCSE qualifications, yet lacked the confidence or ability to express ideas in writing.

The research into student performance in modular examinations was suggested after reading of ‘some small scale research into modular A level physics’ and that ‘There is little research evidence about the benefits of modular assessments in physics at key stage 5 and an absence of research at key stage 4' (Murphy and Whitelegg, 2006, p.50). Having several years of data relating to examination results presented a unique opportunity to explore student performance in the different modules.

The study that I conducted into examination performance (Section 4 of the portfolio), which covered a three year period, provided the opportunity to introduce small but significant changes within the team that have contributed towards consistently improving examination results. The impact of this particular study had a direct impact upon teaching methods within the science department, as it increased our commitment towards developing good written communication skills. Traditionally, physics is regarded as a subject that develops numerical, practical and problem solving skills, which is true, yet during my investigations into examination performance, we realised that we needed to develop students' written (and verbal) communication far more than we had anticipated. This study was of interest to more senior managers within the FEC who recognised that 'drilling down' into modular performance and analysing trends could drive improvements in other subjects.

The report into UCAS destinations (Section 8 of the portfolio) was a unique study that had not been considered before, since the college has only to report on the numbers of students progressing to Higher Education, not on trends in subject choice. The analysis was shared with the Connexions team in order to explore the need for greater links between local employment trends and university courses. Teachers and tutors within the FEC have always been aware that the vast majority of our students choose to study at local universities, yet it was assumed this was for financial reasons. I do not think that we had quite appreciated that this was not necessarily a geographical factor, but a social class factor that applies to all areas of the UK (Reay et al, 2001, 2005, Evans 2009).

The report on careers in science (Section 9 of the portfolio) has also led to an increased and improved partnership with the local Connexions Service, as the study shows that strong careers guidance is essential for young people.

Each of the sections within the portfolio has led towards making positive improvements within the college, either within my own science team or across wider subject disciplines. This has resulted in improved partnerships with local schools, an increase in the numbers of young people who choose to study physics A level (as well as other scientific disciplines) and an increase in the proportion of girls who study physics.

In June 2011, I staged a one day physics event for year nine pupils from local schools (the Ashfield Music Festival). This was so successful that one of our partner schools staged a similar event (November 2011) with a number of our A level physics students going into the school to act as team leaders for the event. A similar festival will take place in June 2012.

My studies have also been shared with professionals from external organisations, which have led to greater partnerships with agencies such as STEMNET, the Institute of Physics, the Science Learning Centres and Connexions. My contributions to the profession have been recognised externally by achieving national recognition from WISE (Women into Science and Engineering), receiving a prize (runner up) for Adviser of the Year (2011).

The need for scientists will increase in order to solve global problems such as climate change, resources, sustainability and to develop new technologies, so it is crucial that we encourage more young people to play an active part in creating this future. The overall contribution of this study will be to recognise the factors that influence subject choice, whether inside or outside of the classroom. It explores the engagement of young people with physics at various levels of education and suggest strategies for increasing participation. The study will also give consideration to the fact that girls are seriously under-represented in physics, at both A level and university, and suggest ways of attracting more girls to study physics.

Chapter 2 Reflections upon a Career in Teaching

The aim of this chapter is to reflect upon my career and explore the most significant factors that have shaped my professional development, as well as the research that is presented within the portfolio. When reflecting upon a career that has covered over twenty years of professional practice, there are many aspects where personal and professional viewpoints are intertwined. For the purpose of this chapter, I will consider four particular phases of my life; my own education (2.1), my early teaching career (2.2), my period within the specialist tutorial team (2.3) and finally the past five years of my career (2.4). The chapter ends with a summary which draws together the themes which have emerged (2.5).

2.1 Reflections upon my education

In order to explore the subject of engagement and participation of young people with physics education, it may useful to reflect upon the reasons why I chose to study physics and the path that led me to undertake this particular study.

At primary school, I was a keen and enthusiastic pupil who enjoyed all aspects of education except sport and 'the nature table'. It was during the seven years at a girls' comprehensive school that I realised my strengths lay in the direction of science and mathematics. After choosing to study additional mathematics O level, this soon became my favourite subject. I thoroughly enjoyed the subject content, with algebra, calculus, trigonometry and geometry being far more interesting, challenging and rewarding than the topics we studied in the ordinary mathematics course. Lessons were always the same, starting with teacher exposition, worked examples and then the pupils practising problems for the remainder of the lesson. There were never any diversions from this routine, which suited my way of learning. Whilst the teacher presented a rather strict and formal approach to her classroom teaching, she would help pupils with any difficulties in a very calm, patient and considerate manner. According to Petty: ‘Of all the attributes of able teachers, the most prized by students is patience’ (Petty, 2009, p.213). I would agree that, on reflection, I preferred the lessons of those teachers who were patient, and whilst I perhaps could not appreciate this at the time, abhorred the teachers who lost their temper with pupils, or used intimidation to control their classrooms.

A further factor that contributed towards my enjoyment of mathematics was my perception of ability with the subject. Kyriacou explains that: ‘For some pupils, doing well at school can develop a positive academic self-concept, which in turn helps sustain further effort and success (creating a virtuous circle)’ (Kyriacou, 2009, p.34). On reading Kyriacou’s discussion of the virtuous circle, I identified strongly with this and could see how this applied to my own learning.

As well as my own perception of my ability, I also enjoyed the fact that my teacher believed in my ability. If there was a problem that I found difficult the teacher would provide detailed feedback on my work, showing a respect for me as an individual, at a time when other teachers did not particularly care about the progress of individual students. I would work hard at practicing the problems until I was sure that I had mastered every topic and achieved a strong sense of satisfaction from knowing that I was good at this subject.

Although I would not have understood at the time, my teacher was demonstrating empathy towards the pupils. Cooper discusses the importance of empathy in good teaching, explaining that empathetic teachers have a positive and affirmative approach, show enthusiasm and develop a culture of mutual respect:

> ‘Students respect and value the teacher if the teacher respects and values them. Crucially, if students and teacher like each other, learning is optimized. This encourages mutual response, engagement and shared enthusiasm leading to learning.’
>
> (Cooper, 2011, p.121)

It is interesting to note that in the years between Cooper’s study and my own education, despite all of the changing educational policies and initiatives, this basic fundamental factor remains constant.

Now that I am a teacher myself and conducting research into why students choose, or do not choose to study physics at A level and beyond, it may be surprising that physics does not merit a mention during this phase in my life. The reasons that I liked mathematics were due to the quiet calm of the lessons, perception of my ability and the continuous support of a kind and caring teacher. These reflections may be extrapolated towards my current studies, as the reasons why students choose particular subjects, whether at GCSE, A level or university, are inherent to all of the sections contained within the portfolio.

Reflecting upon Kyriacou’s Virtuous Circle, and how positive reinforcement encourages success and self-esteem, it is also important to reflect upon the extent that emotions influence the decisions made in life. Damasio studied the biological connection between neuroscience and emotions, and believes that emotions are integral to the process of decision making. Whilst emotions can be explained in a biological sense as a series of chemical and neurological reactions within the body that trigger a range of responses to a situation, he suggests that: ‘The precise composition and dynamics of the emotional responses are shaped in each individual by a unique development and environment’ (Damasio, 1999, p.53).

Some of the more basic emotions equip us with the ability to react to particular situations in order to survive, however, emotions can shape our learning processes in the form of ‘conditioning’ (Damasio, 1999, p.57). He is not suggesting that emotions control our decision making, but that many of the choices we make in life have a certain level of emotional influence: ‘certain levels of emotion processing probably point us to the sector of the decision making space where our reasoning can operate most efficiently’ (Damasio, 1999, p.41). Upon reflection, I can appreciate that in my case, the virtuous circle of success and self-esteem led to an enjoyment of mathematics, which then led to particular emotional responses to the subject and affected subsequent decision making processes.

When choosing my A level subjects, I combined my love of mathematics with physics. This was mainly because physics was the closest subject to mathematics, but I liked the suggestion that the world and everything in it could be represented by equations. Around this time, I became interested in astrophysics, although this was generated by the Carl

Sagan television series on the Cosmos, rather than any encouragement from school (Cosmos: A Personal Voyage, 1980).

The more that I read about astronomy, the more fascinating this subject became. Astronomy is a branch of science that holds wonder for people of all educational levels, which can be demonstrated by the large number of amateurs who are members of astronomical societies. There are currently over 10,000 members of amateur astronomical societies who not only share their interests but can actively contribute towards scientific knowledge (Royal Astronomical Society, 2011). Whilst studying for my A levels, I joined the nearest astronomical society, which was many miles away. It is pleasing to note that one of my first students established the astronomical society within this city in 1993.

I became fascinated by astronomy and believed that this study could answer some of my own questions about religion and our place in the universe. Having been brought up within a strong Roman Catholic family, I wanted to learn more about how the universe was created and believed that the study of astrophysics could lead me in the right direction. Osborne and Collins (2001) suggest that ‘space’ can be a hook for engaging young people with the study of science and I fully agree with this claim. As a teenager, astronomy was the only branch of science that held wonder, excitement and awe, whereas other branches seemed to be about learning laws, rules and things that were discovered in the past. The enjoyment of astronomy therefore triggers an emotional reaction which, as mentioned, informs decision making processes.

Applying these reflections to my current research, I can appreciate that students can be influenced by a wide range of factors outside of the classroom, particularly the media (Kitzinger, 2008). I have included a discussion on the influence of the media in one of the reports in the portfolio (Section 7: Influences Outside of the Classroom), as I believe it is an important external factor for subject choice. Another important factor that shaped my decisions was my family, particularly the support of my parents. Although neither of my parents went to university themselves, they were very proud of my ability and believed in the value of education.

I chose to study for a degree in physics as I believed astrophysics to be a rather specialist subject that would not realistically lead to employment. I had no concept of transferable skills that could be applied to a range of other careers. Whilst I was stronger at mathematics, I thought that physics would lead to a wider choice of employment possibilities in the future. As I attended a girls' school, I was not particularly aware of any gender bias in physics, although the fact that there were only three girls in the class who studied A level physics, whilst there were over forty girls who studied English Literature ought to have been a strong clue. At the time, there were several national campaigns that urged more girls to study science, particularly initiatives such as the Equal Opportunities Commission and WISE (Women into Science and Engineering).

I found the degree course considerably more difficult than I had anticipated and upon reflection, I would have preferred a modular type of course, but that was not an option at the time. I enjoyed topics such as biophysics, geophysics and astrophysics, but could not get excited about the more theoretical aspects of physics. The beauty of physics was in how it explained the world we live in, and whilst ‘relativity’ was an interesting subject, until the time that we can travel at the speed of light, is not a very useful or practical subject to study.

All of the physics lecturers were male, generally middle aged and responded better to the boys than girls. The physics department social activities revolved around particular male cultures (cricket, football and rugby, all to be washed down with copious amounts of this mystifying beverage called ‘real ale’). Upon reflection, my time at university was a wonderful experience where learning was not confined to an academic discipline, but meeting interesting and intelligent people from a range of backgrounds, cultures and nations who shared a common enthusiasm for learning. I was incredibly fortunate to benefit from a system where my university education was free and I received the full grant to enable me to pursue my studies without financial worries. The situation has changed radically since those days, with our current students at the college facing the prospect of paying up to £9,000 per year for their university education.

2.2 Early teaching career

After completing my degree, I found employment in a college, as teaching qualifications were not a necessary requirement for Further Education at that time. I enjoyed working with young adults, so decided to embark upon a Post-Graduate Certificate in Education so that I could develop a career in teaching with the appropriate training and qualifications.

My first teaching position was in a large comprehensive school, which was far removed from the disciplined structure and calm tranquillity of a girls’ school. Having a wide range of ages and abilities to teach, it became increasingly clear why teachers needed to use practical hands-on activities in order to engage the less enthusiastic learners. Whether it was the different ethos of the institution, or the intervening time period, there were far more scientific resources available for teachers, such as videos, computer programmes, electronic kits and practical apparatus. As a physics teacher, I enjoyed the practical aspects of teaching and helping students to make meaning of the concepts.

Hargreaves (1972) discussed the changes in the conception of teachers as they progress from being students to student-teachers to 'fully-fledged teachers'. The differences between the theories of the teaching course and the realities of the profession are compared: 'The student has to face problems which were not considered in the safety of the college seminar and to which he feels he has no answers' (Hargreaves, 1972, p.59). This statement held particular resonance, as I found that many of my creative ideas and initiatives were stifled by internal politics and an expectation to conform to the expectations of the school.

On reflection, my own school teachers had rarely endeavoured to make lessons fun, interesting or enjoyable, counting upon the fact that we were well disciplined, hard working students who did not need to be motivated by the teachers. As a young teacher, I wanted to share my enthusiasm with the pupils and it was an exhilarating feeling when I could captivate some of the disaffected pupils with the wonders of science.

During this phase of my life, I embarked upon a part time M.Sc. in astrophysics at my former university. This was a unique opportunity as the department did not offer masters programmes. My former tutor, however, with whom I had maintained contact since graduating, offered me a place to work within his research team. The study involved the analysis of computerised polarisation data of the nebula NGC 2264 in order to determine the source of its luminosity (Hill, M.C.M., 1991, The polarisation of the Cone (IRN) Nebula in NGC 2264, M.Sc. Durham University).

Whilst it was difficult to combine research with full time employment, being a student at the same time as being a teacher made me constantly aware of how the learners feel with regards to the teaching and learning process. According to Brookfield: 'Experiencing what it feels like to learn something unfamiliar and difficult is the best way to help teachers to empathise with the emotions and feelings of their own learners as they begin to traverse new intellectual terrains' (Boud, Cohen and Walker, 1993, p.21).

Whilst I enjoyed working in a school, I yearned to teach A level and moved to a College of Further Education (FEC) in 1990. When I started my employment at the FEC, the optional modules in A level physics were electronics and particle physics. There was a cohort of students for whom neither of these modules appealed, so I developed the optional module in astrophysics. This was particularly popular with many of the students, who subsequently achieved good results.

At this time, there was a strong interest within physics education for the appeal of topics that were related to people. Jones and Kirk (1990) discussed the appeal of medical physics (particularly for girls) and later, Stewart (1998) suggested that physics topics that held some social content would appeal to girls. Whilst this is clearly a generalisation, I was keen to develop a medical physics module, and found that it appealed to both boys and girls as a number of our students progressed to study health related careers. In Sections 1 and 2 of the portfolio, I found that pharmacy was a particularly popular career for students at the FEC. Therefore medical physics held more appeal for students wishing to pursue careers in the health professions. One of my male colleagues would refer to these two modules as ‘fluffy physics’ and would insinuate that these modules were ‘for the girls’.

The male teachers within the physics team believed that nuclear physics and electronics provided the best foundation for a career in physics, which may be true, but the reality was that not many of our students progressed onto physics degree courses. I would argue that we must allow the students to choose those modules which would motivate and encourage them towards achieving the best grade possible.

I believed this to be true for many years, however in retrospect, this may have been a rather simplistic viewpoint. I later found from first-hand experience that allowing students to select an optional module did not necessarily lead to a stronger examination result. The question of whether it was more important to teach options which students found interesting or those which would lead to stronger examination results was the fundamental reason for the investigation into the under-achievement of students in the Health Physics module (Section 4 of the portfolio).

These early years at the college were a very happy phase of my life, when a culture of mutual respect pervaded the college. The students were there by choice and they worked hard to achieve success. At the time, college lecturers had better salaries, terms and conditions than school teachers and there was an excellent rapport between colleagues and managers of all levels.

During these years, I also held a tutorial role and thoroughly enjoyed helping students through an important time in their lives, negotiating the transition from childhood to adulthood. Coleman (1994) writes about the pressures young people face in the transition to adulthood, with a combination of internal pressures (physiological and emotional) as well as external pressures (peers, parents, teachers and society). He suggests: ‘While independence at times appears to be a rewarding goal, there are moments when it is a worrying, even frightening prospect’ (Coleman, 1994, p.61). I enjoyed helping the students with personal as well as academic issues, and fully believed that strong pastoral support was essential for students to make the transition from school to college and then to university or employment.

After the implementation of Curriculum 2000 (and the FEC’s Widening Participation agenda), the number of AS students increased significantly, recruiting more students from diverse backgrounds. It soon became apparent that whilst the number of students who enrolled at the college had increased, retention and achievement became a particular problem. The senior management at the FEC were alerted to the success of Greenhead College in Huddersfield, which had achieved outstanding results with students from similar social backgrounds. In an article featured in the Guardian in 2001: ‘Greenhead is one of the highest performing sixth-form colleges in the land -

and a Beacon College to boot - and their principal a CBE. The students and staff deliver' (Kingston, 2001).

This national acclaim caught the attention of our management and they visited Greenhead College to determine the reasons for this success. One of the main factors was the investment in a pastoral team who were dedicated towards supporting students. Tutors were in the form of Learning Managers, who were highly skilled in dealing with student issues (academic as well as pastoral). The specialist tutors at Greenhead College were paid a higher salary to reflect the importance of this position. Until this point, tutorial groups at the FEC were allocated to those teachers with spaces on their timetable rather than considering the personal skills required for this role.

After visiting Greenhead College, the FEC decided to invest in a stronger pastoral system that set clear targets and aspirations for students. Having taught A level physics for ten years, I was ready for a change in direction as well as the promotion that this position would offer.

2.3 The pastoral years

In 2001, I was invited to join the specialist tutorial team although this required moving out of the science department completely. It was at a time in my life, however, when I was ready for a new challenge and a promoted position. The head of the tutorial team was a woman with great energy, enthusiasm and vision, being absolutely determined to create a strong and dedicated pastoral team. She was greatly impressed by the work of Geoff Petty, having attended a number of his workshops and found his teachings to be inspirational. Petty is the author of *Teaching Today: A practical guide*, which has now reached its fourth edition. According to the Nelson Thorne website:

‘Geoff Petty has a reputation for explaining teaching and learning issues in a down-to-earth but lively and inspiring way’ (Nelson Thorne, 2009). Through this leadership, we all believed that the tutorial programme was the cement that bound together the other subjects and that we were instrumental in creating the framework for the students to learn at college.

With the increase in students from diverse backgrounds, our aspirations were to help as many of the students as possible overcome some of the most difficult of circumstances and achieve success in employment or higher education. We were, at all times, clear that the main purpose of the team was to ensure that the FEC achieved strong retention and achievement results. The head of tutorial demonstrated a strong commitment towards the team, which was inspiring for all of us and we worked tirelessly to provide the environment and structure necessary for all students to thrive, whatever their home background.

Cooper discussed the fact that some young people gain a ‘new lease of life’ when they move from school to further education, as they prefer the more informal relationships with staff and the adult environment. Many students bring ‘emotional baggage’ from their secondary schools with some students having low self-esteem (Cooper, 2011, p.196). This is certainly applicable to the FEC, with many students coming to college simply because there is no other realistic alternative (either education or employment).

During this phase of my teaching career, I was in a department which was far removed from my original training and area of expertise. I found that I was required to teach Critical Thinking, General Studies and Citizenship, which were subjects that were completely different to the precise and well-defined world of physics. Citizenship was a new subject to the college, a course that would prepare ‘A’ level students for living in this country as adults and would be delivered by the tutors. It comprised elements of politics, history, law, sociology and media studies. In fact, it covered vast areas of knowledge that I wish I had been taught whilst I was at school. Initially, I was rather apprehensive about teaching this subject as the course required extensive factual information and understanding of a wide range of social and political issues. Teaching this subject required far more planning and preparation than I had ever needed as a physics teacher.

It was during this phase of my life that I learned the most about what constitutes good teaching practice, as well as a wide variety of social and interpersonal skills that were necessary for teaching a more diverse group of students. It was a period when my learning experiences were in phase with my students, as I learned so much about politics, sociology, humanities and the arts. Instead of ‘What am I going to teach the students’, my teaching became ‘What are the students going to get from this session?’ Within section 4.3 of this report, I discuss the work of Jean McNiff, whom I have found inspirational. She believes that good teachers are learning all the time, and dedicate themselves to the education of themselves in the interests of others (McNiff, 1993, p.21).

Apart from the tutorial programme and teaching the ‘Enrichment’ subjects, pastoral care encompassed other responsibilities such as:

1) Academic progress

2) General behaviour and attitudes

3) Personal and social development

4) Individual needs

(Kyriacou, 2009, p.115)

Our task was to integrate these features into the pastoral provision, as it was increasingly found that the young people coming to the FEC required considerable guidance and support throughout their studies. This aspect of my role drew upon a far greater range of inter-personal skills than I had ever, until then, used within my teaching practice. Ron Best has produced several texts on pastoral care and explains that young people need not only guidance and security, but also moral and emotional support (Best, 1995, p.11).

In section 3.4.1 of this report, there is discussion of Vygotsky and the Zone of Proximal Development. This is the area between what the student can currently master and the next step which the student can achieve with adult guidance. Cooper (2004) draws upon the work of Vygotsky to suggest that the learner's personal and academic development are continually interlinked. She extends the concept of the Zone of Proximal Development to include affective assessment and emotional scaffolding, and suggests that caring teachers create the right climate for young people to learn effectively. 'Formative assessment, which is at the heart of learning, needs to be both emotional and cognitive, both personal and academic' (Cooper, 2004, p.18). This can be applied towards my pastoral role at the FEC, where the tutors provide the guidance and scaffolding to enable students to progress from school pupils at the age of sixteen to young adults who then proceed to higher education.

Within this role, I learned about the vast spectrum of students within the FEC and of the many barriers and background problems that prevent young people from realising their true educational and personal potential. As Kyriacou points out, pastoral care may include serious personal problems such as juvenile delinquency, illness, incest, emotional disturbance and bullying (Kyriacou, 2009, p.116). A considerable amount of my work in this role involved liaising with outside agencies such as Connexions and Social Services, as well as dealing with child protection issues. Some of the cases that I had to deal with were particularly harrowing, so I attended training in counselling to ensure that I was prepared to meet the needs of the more diverse problems experienced by students. A student's personal history has a significant effect upon their learning experience. As a tutor, it was often surprising, sometimes shocking, what some of the students had experienced outside of college and this would undoubtedly have influenced their education:

> 'The characteristics and aspirations of the learner are the most important factors in the learning process. The response of the learner to new experience is determined significantly by past experiences which have contributed to the ways in which the learner perceives the world.'
>
> (Boud, Keogh and Walker, 1985, p.2)

During this period, I found that helping students to overcome, or cope with problems and see them succeed, despite their disadvantages, gave a much greater satisfaction and meaning to my life than merely teaching my own subject. As Schön has stated: 'As the professional moves toward new competences, he gives up some familiar sources of satisfaction and opens himself to new ones' (Schön, 1983, p.299). This is a simple phrase but one which summarises the experience succinctly, for I had moved away from the satisfaction that I knew from teaching science and in doing so, found many new and unexpected sources of professional satisfaction.

Jarvis, in *The Theory and Practice of Teaching* discussed the increase in separate pastoral provision, with specialist 'academic advisors' (rather than subject teachers) to provide continuity, guidance and counselling for students. He comments, in an admittedly cynical manner, that these offer a 'customer services role' to help the students (Jarvis, 2006, p.239). I would agree that the nature of pastoral care has changed in further education over the past ten years, however it is necessary to provide this support if we wish to widen participation from sectors of society that have not been able to access education in the past.

A Lecturer's Guide to Further Education provides another critical view of the support necessary for students within Further Education:

> 'Constant government interference over the last three decades has transformed them from the traditional 'tech', first into youth containment camps and then, as a result of more and more interventions focused upon individuals and their personalities, into therapy centres.'
>
> (Hayes, Marshall and Turner, 2007, p.1)

They claim that the 'therapy' involves the increased concern with the private and emotional lives of students. The key point in this statement is where they state that the changes have occurred over the past three decades. Education is always changing and evolving, and if this change allows more students from non-traditional backgrounds to access further or higher education, then I am fully in support. As Kyriacou points out, pastoral care supports effective teaching as it shows that the establishment cares about the individual's progress and well being (Kyriacou, 2009, p.117).

2.4 The past five years

In 2006, there were several changes within the FEC implemented by a new senior management team (internal), as well as changes to funding arrangements (external), that prompted my decision to return to science teaching. I made a lateral move to the position of Science Team Leader at one of the Sixth Form Colleges (that are part of the larger FEC), as I believed that it would offer greater long term career security. Through my pastoral experience, I was far more interested in the learning process of the student, rather than how much of the syllabus I could cover in a lesson.

My experiences within the pastoral team made me far more conscious of my own teaching practice. I was fully aware that the amount of material covered is insignificant if you have not got the attention or interest of the learner. Whilst I have always been enthusiastic about science, I realised how important it is to show students how much you care about the subject.

According to Muijs and Reynolds in *Effective Teaching*: 'An important component of classroom climate is the enthusiasm shown by the teacher' (Muijs and Reyolds, 2005, p.110). They discuss the fact that teachers who enjoy teaching their subject can motivate students more than those teachers who do not show enthusiasm, claiming that when adults are asked to recall good teachers, they remember those who inspired and motivated through enthusiasm (Muijs and Reynolds, 2005, p.110). Kyriacou also listed teacher enthusiasm as one of the most important variables in what actually goes on within the classroom (Kyriacou, 2009, p.8). Cooper explains that a teacher's enthusiasm and energy is infectious and triggers a mirrored response in students (Cooper, 2011, p.122).

Many of the students who attend college have considerable social, domestic or personal problems that have an adverse affect upon their education. It is crucial to provide a safe haven for all students to be recognised, valued and cared for, and when you have the right environment, the learning for these students can begin. Within my physics lessons, I try to teach through a variety of activities and understand that each student is a unique individual with their own personal experiences and needs. As Boud, Cohen and Walker claim: 'We bring the whole of our life into every learning event and any aspect of our past may be brought into play.' (Boud, Cohen and Walker, 1993, p.8)

A good teacher needs to know the backgrounds of their students and their motivations for doing the course, and must also empathise with the students. As Kyriacou explains:

> 'It is of prime importance in fostering pupil motivation that the teacher maintains a stance of conveying the view, through their actions and expectations, that academic work is interesting, worthwhile and of value, and that the progress of each pupil really does matter.'
>
> (Kyriacou, 2009, p.63)

Another important factor is to believe in the students themselves. A very influential study was conducted in the 1960s on the issue of 'self-fulfilling prophecies'. In this study, a 'test' was conducted with American primary school children and the teachers were informed of which pupils had scored highest marks. In the subsequent year, these pupils (who had been chosen at random) made significant progress. This study showed that teachers' expectations influenced their behaviour and attitude towards the pupils and produced a 'self-fulfilling prophecy' (Kyriacou, 2009, p.34).

A good teacher has knowledge, expertise and confidence in their teaching, can respond to individual as well as group needs, relates well with young people and ultimately inspires learning beyond the classroom. According to Murphy and Whitelegg:

> 'The strategies that maintain students' autonomy and responsibility for their learning include investigatory laboratory work, group and class discussions where alternative views are considered and valued, problem solving and project based activities where students are the decision makers, and creative writing involving a range of genres in which science understanding is communicated to the public.'
>
> (Murphy and Whitelegg, 2006, p.28)

A variety of teaching and learning styles is important, and this sometimes means that students will have to face challenging situations, such as making presentations to the class. This is one of the least favoured classroom activities for physics students. In order to prepare students for A level examination success, as well as future employment and higher education, we must not only engage our students but develop a wider range of skills which they may not particularly like, enjoy or appreciate at the time.

Having conducted the first report into examination performance in the physics modules, I found that students under-achieved in the health physics module, but this was primarily due to the amount of writing required in that particular examination. Since then, I have placed far more emphasis upon developing written communication skills, as many of our students have weaknesses in this area. Unfortunately, many of our students express a strong dislike for written communication, and it is clear that teaching up to GCSE involves short ‘bite-size’ activities that do not involve any form of extended writing.

At the FEC, teachers are judged not only on achievement (pass rates), but also on the retention of students and the responses from student surveys. The students are particularly forthright in the ‘Quality Surveys’ and provide negative feedback for any teaching activities which they do not like. Teachers must be strong enough to withstand the fact that students confuse ‘wants’ with ‘needs’. As Noddings states: ‘Not every want rises to the level of need’ (Noddings, 2005, p.149) and discusses the fact that ‘needs’ are for the longer term benefit of the students. Brookfield also discusses the difference between wants and needs:

> ‘The trouble with the ‘meeting needs’ rationale is not just that it sets up an unattainable standard, but that students sometimes take a dangerously narrow view of their needs. Students who define their needs as never straying beyond comfortable ways of thinking, acting and learning are not always in the best position to judge what is in their own interests.’
>
> (Brookfield, 1995, p.20)

On one hand, teachers must ensure that students enjoy all lessons and provide positive responses in the quality surveys, yet it is imperative to develop the skills necessary for examination success.

Over recent years, I have become increasingly concerned with the short concentration spans of many students. As Bryan and Hayes discuss in ‘The McDonalisation of Further Education’:

> ‘McStudents demand that McLecturers efficiently spoon feed easily digestible McNuggets of knowledge and skills, so they can fill their portfolio and get through their exams.‘
>
> (Hayes, Marshall and Turner, 2007, p.50)

The bite size mentality has been promulgated by websites such as the BBC revision site for GCSE (www.bbc/bitesize, BBC, 2011), which provides for the short concentration spans of young people. I fully believe that one of the key differences in the achievement of higher grades at A level is the ability to persevere with difficult or extended problems and maintain concentration. Steinborn et al. investigated the importance of concentration, claiming:

> 'Although several studies have related intellectual ability, personality and motivational variables to school achievement, very few have investigated concentration, despite the fact that the ability to sustain and regulate mental focus over extended periods of time is an important prerequisite in almost every domain of learning and skill acquisition.'
>
> (Steinborn et al. 2008, p.614)

My interest in sustained concentration led to the development of some of the Higher Order Thinking Skills tasks which are in the portfolio (Section 3).

Having returned to the science department after an absence of five years, I was concerned that despite the growth of the college, the number of students who had chosen to study physics, whether at AS, A level or as a degree subject had decreased. At this time, there was only one of the four local universities that offered a degree course in physics (although the requirements were generally three A grades at A level). Since the majority of students from the FEC only consider local universities (88% of students from the FEC proceeded to local universities in 2011), and only exceptional students achieve three A grades. This led to a situation where students were saying that they really wanted to study for a degree in physics yet would have to study chemistry instead, so that they could live at home during their degree studies.

From a personal as well as professional point of view, I was ready to take some sort of action to increase the number of students who progress from our partner schools to the FEC to study physics, as well as progress onto degree courses in physics-related subjects.

The opportunity to study for a Professional Doctorate was offered to staff at the FEC and this seemed to present an appropriate vehicle for studying this problem in a formal manner. Through the work that I have been conducting, I have engaged with a range of external agencies, which has had a positive effect upon my professional development.

Whilst I made good use of the Institute of Physics material in the past, I decided to join as a member in 2008. The IOP has provided valuable resources, contacts and support throughout my studies. The Action Research Project that I conducted with the Science Learning Centre provided further professional development and the opportunity to work with physics teachers from other educational establishments. This was an excellent opportunity to reflect upon teaching in a supportive external environment.

Whilst working towards the professional doctorate, I have worked with other external agencies such as STEMNET and professionals from other organisations (e.g. Connexions). I have also sought advice from agencies such as WISE, examination boards and universities. Working with all of these external agencies has contributed towards a greater understanding of the original key research questions from a variety of perspectives. It has also provided a network of professional contacts that can support and enhance my future professional role at the college. Through working with these agencies, I have encouraged colleagues to undertake their own Action Research Projects in areas related to science and mathematics (Bridging the gap from GCSE to A level and the use of smart phones for educational purposes).

Whilst conducting research for the sections within the portfolio, I have worked with a range of support teams within the FEC, and been in a position to ask for information from a range of senior managers. Whilst my original proposal was supported by the Assistant Principal (2008), some of my subsequent requests for information from different areas of the college have not received the full support from college.

The work that I have undertaken for the Professional Doctorate programme has provided a stronger understanding of all of the factors associated with science education, both inside and outside of the classroom. This has made a direct impact upon my team, where we are continually striving to increase the number of A level students, improve the success rates and encourage students to study science related subjects at university.

As a manager within education, I believe in the importance of collaborative working, and the development and sharing of good practice. Unfortunately, there are many teachers who are cynical towards new initiatives driven by the Quality Unit or Directors of Learning, so it was pleasing to find that the platform of the professional doctorate was not at all threatening for colleagues and encouraged a wider co-operation and engagement of the team. Nias found that teams developed a mutually supportive relationship when working and learning together and that: 'even when collaboration takes place in order to enhance students' learning, teachers themselves often develop and change in the process' (Biott and Nias, 1992, p.xiv). I believe that during the course of my studies, the sharing of good practice has increased, and discussions around teaching and learning are the most prominent feature of our day to day conversation, rather than being only discussed at meetings or training sessions.

Whilst studying for the professional doctorate, my role at the college has gradually been extended from Science Team Leader to my current role of Curriculum Leader for Science, Mathematics and Psychology across two sixth forms, with far more staff and students to manage. Conducting this study has also raised my awareness of the wider political framework that structures and undergirds many of the decisions made in education today.

2.5 Summary

According to Petty: 'Good teachers are not born, nor are they made by tutors, they make themselves' (Petty, 2009, P.516). He explains that there is no personality type that makes the best teacher, and the only way to be an effective teacher is to learn by mistakes and successes. One may teach for many years, but practice does not make perfect unless you reflect upon your practice with the intention of learning from your own experience (Petty, 2009, p.516).

Brookfield states: 'Investigating our autobiographies as teachers is the first step on the critical path' (Brookfield, 1995, p.29). He believes that autobiographies, as either learners or teachers, are the first of four 'lenses' through which we can view our teaching. The other lenses being: 'Our students' eyes, our colleagues' experiences and theoretical literature' (Brookfield, 1995, p.29). During the course of this study, I have actively used these ‘lenses’ in order to structure my research, my evaluation and the recommendations. This chapter is my own ‘lens’; my personal account of the factors that influenced my education and career.

As Brookfield points out, however, there are flaws to this method of self-analysis due to ‘how much we’re cooking the data of our memories and experience to produce images and renditions that show us off to good effect’ but he firmly believes that reflecting upon our own experience is absolutely essential to becoming a critically reflective practitioner (Brookfield, 1995, p.33).

Through this autobiographical account, I have had the opportunity to critically reflect upon my professional practice as a teacher. Whilst my own preferred learning styles and preferences shaped my earlier career within the profession, my approach to teaching was significantly altered by the period outside of my particular area of expertise. During this phase, I learned about the diverse range of student problems, how to teach a more diverse range of subjects, new teaching skills and strategies, but most importantly, I learned to reflect critically upon my own practice.

Within several sections of the portfolio, there is clear evidence of seeking the views of students (the lens of the students); the focus group in section 1, the survey in section 3, written evaluations in section 5, discussion group in section 7 and case studies in section 10.

For each of the sections in the portfolio, I have showed my work to professionals both inside the organisation (the FEC) and external agencies, in order to seek the opinions and constructive advice (the lens of colleagues).

This chapter has presented a reflection upon my career in teaching, which was the starting point for embarking upon the professional doctorate programme. The next chapter will present a literature review of recent research that has been conducted into physics education, providing an important reference point for extending the current understanding of the problem, determining areas that required further research and how I can contribute towards this field.

Chapter 3 Literature Review

This chapter will review the literature relating to this study. Initially, the research focussed upon studies relating to physics education. As the sections within the portfolio developed, it became clear that many of the factors that influence young people are outside of the classroom and it was necessary to widen my background reading.

This chapter draws upon the literature which has shaped my studies, starting with government reports which highlight the need to increase young people's engagement with STEM subjects (3.1). The next section of this chapter will explore some of the academic research relating to physics education in the classroom (3.2), then consider some of the wider external educational issues (3.3.). The final section will discuss some of the more generic pedagogical issues which underpin my studies, many of which have increased in importance as the study progressed (3.4).

3.1 Government reports into STEM

Several government reports have highlighted the need to increase the number of young people who study science at all levels of education.

SET for Success (HM Treasury, 2002)

This report (which is also known as the Robert's Review) identified several concerns about science education and made recommendations to improve the situation. It contextualises the need for such a report by claiming that between 1995 and 2000, the number of students who entered higher education increased by 10%, yet the number of students who pursued courses in science and technology decreased by 7%. The number of young people studying maths and physical sciences fell by 1% (Section 1.8). Within science departments at universities, the growth areas appear to be bioscience and computer science courses (Section 1.8).

The report states that because there are a wide variety of employment opportunities open to STEM graduates, this has resulted in a shortage of specialist teachers in STEM subjects (Section 0.6). The report also claims that maths and physics graduates are more likely to develop careers in the financial services sector, whereas graduates in biological science were more likely to work in education (Section 1.15). This is a very important point, particularly as this study established that there is a shortage of specialist physics teachers within the partner schools of the FEC. This issue was raised by the focus group in Section 1 of the portfolio and will be discussed further within Chapter 5 of this report.

The report highlights a need for Continuous Professional Development for science teachers and made a recommendation to introduce the new Science Learning Centres in order to promote quality science teaching throughout the country (Sections 0.19, 2.70 - 2.74). The report made reference to four main factors which influence a student's achievement and enthusiasm within a particular subject:

a) The teacher, including their particular style and methods of teaching

b) The teaching environment

c) The subject curricula and extra-curricular activities

d) Other influences such as parents and the wider aspects of society

(Section 2.33)

Although subject knowledge and teaching style are ‘vital factors’, the report states that it is the enthusiasm of the teacher that captures a pupil’s interest and motivates them to study a subject (Section 2.35). This factor reinforces my own personal experiences as outlined in the previous chapter. The report also expressed concern at the low number of female students opting for these subjects, both at A level and at university (Section 0.9).

The Science and Innovation Investment Framework 2004 – 2014

(HM Treasury, 2004)

This report outlines the need to invest in STEM education in order to contribute towards greater scientific research and development, which would then lead to greater economic growth for the UK. The first chapter outlines why ‘harnessing innovation in Britain is key to improving the country’s future wealth creation prospects’ (Section 1.1). The report states that there should be greater collaboration between universities and employers: ‘There is an economic imperative to make sure that scientific knowledge is used by business to create wealth’ (Section 5.1). An interesting feature of this report is that it suggests the salaries of Advanced Skills Teachers in science should be deregulated so that they are paid a minimum of £40,000 per annum (Section 6.21).

The report expressed concern about the post-16 sector of education, claiming that there has been a 13% drop in the number of students who choose to study A level maths and physics since 1995, along with a 15% drop for A level chemistry (Section 6.34). It states that this decrease has been alongside a steady growth in the number of students who are choosing A levels in business, psychology and media/TV/film studies:

> 'However, there is lack of robust national data on the recruitment and retention of SET post-16 teachers. The government recognises that this is needed urgently. To further understand when and why teachers leave the sector, DfES will undertake rapid, focussed research to fill the information gaps about the SET workforce in the post 16 learning and skills sector. Early indications will be available by March 2005.'
>
> (Section 6.38)

The report expressed concerns that STEM teachers were leaving this sector of education and that there was a need to determine the reasons for this situation (Box 6.1). This section on post-16 education is particularly relevant as it relates to the FEC upon which this study is based. Since 1992, each college of Further Education has operated as an independent company, which must remain financially viable in order to survive in the ever-changing educational market. Each college has independent organisational structures, staff contracts, terms and conditions.

Over the past twenty years or so, the salaries of teachers in the FE sector have decreased markedly in comparison to school teachers, along with fewer holidays, more teaching hours per week and greater accountability (pressure) for success rates. It is rather disingenuous for a government report to suggest that it needs to conduct research into why teachers are leaving the post-16 sector. I believe that the rapid turnover of staff (in some institutions) reflects the current instability of this level of education. Of the STEM teachers who have left the FEC in recent years, the main reasons have been associated with the demands of the job, along with the terms and conditions of employment.

The STEM Review (Smith, 2007) published by The Council for Industry and Higher Education was a report on how the recommendations from 'SET for Success' (2002) have been implemented. The main conclusions included:

1) The number of STEM graduates has increased since 2002, but the number of students taking A levels in mathematics, physics and computer sciences has decreased.

2) The 'Golden Hello' initiative is an attractive incentive for teachers of STEM subjects, but this needs to be sustained, particularly in order to address gender and ethnic imbalances within the profession.

3) The original report suggested improvements to both teachers' CPD and school laboratory provision, neither of which have improved at the rate expected.

4) Career guidance has remained 'patchy' and this area requires further improvement. (p.2-3)

The report made a number of further recommendations, such as increased weighting of UCAS points for STEM subjects, government bursaries for STEM subjects and further incentives to attract and retain STEM teachers. It suggested greater collaboration between employers and education in order to raise awareness of potential careers that can follow from studying STEM subjects at school. The STEMNET organisation provides an ambassador scheme which allows science and engineering professionals to work with young people and engage in a wide range of educational activities.

The report also made reference to the importance of parents: ‘The initial interest and enthusiasm for STEM on the part of the student can easily be snuffed out if the parents’ view is that studying science can only close down options’ (p.12). It was acknowledged that parents can be very difficult to influence and need to have a greater understanding of the issues.

Taking Stock, the CBI Education and Skills Survey **(CBI, 2008)**, identified that the UK faces potential skills shortages for scientists, particularly at graduate level. The report indicated that 59% of firms that employ STEM-skilled staff are having difficulties in recruitment and that some sectors are experiencing acute shortages. Some of the larger firms have to recruit internationally, with 36% of these employers recruiting from India and 24% from China (p.26). Some of the main issues that must be addressed in order to increase the number of young people with STEM skills include good career advice, specialist teachers (particularly for the teaching of physics), up to date laboratories where ‘practical science can fire the imagination and create a passion for the subject’ (p.29).

The Annual Innovation Report (DIUS, 2008) states that the number of young people taking science subjects has increased by 7% since 2000 (p.43). It presents the case that improvements are being made through initiatives to increase the number of science teachers, the development of the Science Learning Centres, and investment in careers education (p.44).

The report also makes reference to STEMNET, claiming that this organisation now has over 20,000 role models to inspire young people and represents over 1,000 employers (p.44). Whilst STEMNET can provide a good support network in Science, the ability to provide ambassadors or role models will clearly vary with the geographic region, with some areas having access to more ambassadors than others.

To summarise, there have been a number of government reports produced in recent years to consider the issues associated with science education and how to encourage more young people to study STEM subjects. There have been a range of recommendations, some of which (for example, the implementation of the Science Learning Centre and STEMNET) have been very successful. Some of the other recommendations, such as initiatives to attract and retain specialist teachers, improvements to teaching environments and specialist careers advice have not been introduced according to the recommendations. These reports are discussed in more detail in Sections 1 and 2 of the portfolio, which explore the progression of young people from GCSE to A level, then from A level to degree study. The Action Research Project (Section 5 of the portfolio) was conducted through the Science Learning Centre. The support provided by both the Science Learning Centres and STEMNET are discussed in Section 6 of the portfolio. Some of the wider influences, as suggested by the Set for Success Report, such as the influence of parents and society are discussed in Section 7 of the portfolio.

3.2 Physics education in the classroom

All of the literature on physics education (in the last thirty years) makes reference at some point to the low participation of girls in physics. This has been a concern since 1975 when the Equal Opportunities Commission highlighted the gender imbalance. Since then, there has been considerable research to explore the reasons why girls are not attracted to physics. This is an important issue, however, it is acknowledged that any classroom strategies that have been developed to improve the physics education of girls, also have a positive impact upon the education of boys (Murphy and Whitelegg, 2006, p.28).

The Murphy and Whitelegg Report (2006) was commissioned by the Institute of Physics in order to draw together all of the recent research that has been conducted into the issue of girls and physics ('Girls in the Physics Classroom: A Review of Research on the Participation of Girls in Physics'). This report was based upon 177 sources of information, including books, research reports, journal articles and conference papers produced in the UK between 1990 and 2005. The report was supplemented by additional research from other countries that have similar educational systems to the UK. It incorporates the most significant pieces of research into physics education in recent years, irrespective of the gender issues.

The report begins by outlining the problem, which is essentially that between 1996 and 2006 there has been a decrease in the number of students studying physics at university, with 30% of physics departments closing since 1997 (Murphy and Whitelegg, 2006, p.1). The report states that if girls were represented more proportionally, then this would help to increase the overall numbers of physicists. The decline in the number of young people studying physics is important as it will decrease the skills and knowledge of the future workforce, as well as future teachers who may not have the qualifications and background to teach physics and enthuse the next generation of potential physicists.

Whilst the brief of their report was to explore research that has been conducted into girls and physics, this does not, nor can not, exempt or preclude boys from the research. Most of the educational research available considers education of boys, whether as a parallel or comparative factor:

> 'The analysis of these gender differences is complex and indicates a number of interacting influences. There is no simple solution and many long standing beliefs about the reasons for girls' alienation from physics have been contested in literature…the problem is deep rooted, multi-faced and thus difficult to solve. However, as society changes, so do the possibilities and constraints, so it is crucial to understand the current experience of students in the physics classroom.'
>
> (Murphy and Whitelegg, 2006, Executive Summary p.iii)

Murphy and Whitelegg outline a particular problem in the very definition of gender, in that it may be inappropriate to conflate the term 'gender' with 'biological sex' (This is discussed further in Section 4.4 of this report). They make it clear that when discussing differences between girls and boys, they are referring to trends for a group that are not necessarily attributable to all members of that group. Murphy and Whitelegg discovered that recent research (i.e. in the past ten years) into gender and physics was rather limited, thereby indicating a need for further research into this particular issue:

> ‘It is a matter of considerable concern that, despite the identification of the problem, we still do not have research-based understanding of why gender has such a profound impact upon choice of physics post-16 in England. It is vital that this is not allowed to continue.’
>
> (Murphy and Whitelegg, 2006, Executive summary p.v)

Another problem they encountered when compiling their literature review was that most of the studies for the pre-16 age range were concerned with science rather than physics, as many GCSE students in England and Wales study a double award science course rather than separate sciences. Within this part of the chapter, I will consider the research that has been conducted into physics education based upon:

Physics as in interesting subject	(3.2.1)
The importance of good teaching	(3.2.2)
Physics as a difficult subject	(3.2.3)
Methods of assessment	(3.2.4)

3.2.1 Physics as an interesting subject

At this point, it is important to differentiate between the terms ‘interest’ and ‘relevance’; the former is concerned with how the student finds the topics covered within the classroom, whereas the latter is concerned with how the students perceive the subject to be relevant outside of the classroom, and will be discussed later in this chapter (Section 3.3). Elwood and Comber (1996) conducted a survey of 247 students from years 12 and 13 in England and questioned their attitudes towards the physics A level syllabus. They reported that:

a) The majority of students reported high levels of confidence, motivation, enthusiasm and enjoyment.

b) Female students' enjoyment was more positive than that of the males.

c) Whilst both male and female students considered physics to be relevant, they were not intending to study physics at university.

d) Both male and female students considered the subject to be socially relevant.

Stewart (1998) conducted a study of A level physics students in English schools and found that even at the post-compulsory level, gender differences were still apparent: 'Whether or not the fact that small numbers of girls opt to study physics at A level and beyond should be considered a problem or just a fact of life is open to debate' (Stewart, 1998, p.283). Stewart claims that in the past, the gender gap was due to a lack of opportunity for females, where girls were encouraged to study certain subjects. The National Curriculum, when introduced in 1988 made the study of science compulsory for all pupils and this ensured that girls, as well as boys, continued their science education.

Stewart discusses the influence of early childhood, home environment, the local community and the media, as factors playing a crucial role in developing a child's interest and perception. Early socialisation, through toys, hobbies and activities may cause children to develop a gender identity, and traditionally physics has had a masculine image. Further areas that Stewart explores are the content and context of physics, the classroom environment and whether single sex schooling makes a difference.

Stewart's research was based upon questionnaires sent to A level physics students who were at the end of the first year of sixth form. The aim was to investigate the attitudes of those students who had already made the decision to study physics at post-compulsory level, therefore expecting all students to have a positive attitude towards physics. The survey was conducted in the West Midlands and 128 students responded to the survey (93 male, 35 female). From the sample, one of the immediate findings was that the girls were 'streets ahead' of the boys in performance at GCSE English, as well as having a higher general academic ability (Stewart, 1998, p.287).

From her study, Stewart found that boys were more interested in the mathematical content of the course whilst the girls expressed an interest in the sociological content. This latter factor has been explored in Section 4 of the portfolio (Student Performance in A level Physics Modular Examinations), having introduced the health physics module at the FEC in order to directly appeal to girls, yet we found that just because girls were interested in a subject did not lead directly towards improved performance in examinations.

Research into pupils' perceptions of science was conducted by Osborne and Collins (2001). They held 20 focus groups (144 pupils) in London, Leeds and Birmingham. The groups were split according to gender and whether they wished to continue science after their GCSEs, making four distinct categories of participants. All of the focus groups were taped, transcribed and then coded so that the results could be analysed with a data analysis programme. There were many positive aspects to the study, as the majority of pupils believed that science was important as it is 'all around us'

(Osborne and Collins, 2001, p.446). They also found that the pupils thought that the study of science was ‘prestigious’ and those who study science were more ‘intellectually able’. One of the main reasons that pupils believed science was important was its relevance to a future career, rather than interest in the subject itself.

Osborne and Collins expected to find that physics would emerge as the least relevant science subject, so they were surprised to find that chemistry held the least relevance for the pupils. They found that the girls in both groups made more negative comments about physics than boys, which they claimed ‘would suggest that school physics still lacks appeal for girls’ (Osborne and Collins, 2001, p.449).

It is interesting to note that this paper states that girls were far better at articulating responses and expressing their thoughts than boys. Osborne and Collins suggest that physics lacks appeal for girls based upon contributions to a focus group, yet could it be that boys were less able to express their thoughts or contribute to the discussion than the girls? As stated in the report: ‘Boys, in contrast, had little to say about the importance of science either to themselves or to their everyday lives’ (Osborne and Collins, 2001, p.448).

An interesting point is that the interests of both boys and girls who were not continuing with science were very similar, and distinct from those who were going to study science post-16. For both the boys and girls who were not intending to continue with science education post-16, biology was the most popular science (Osborne and Collins, 2001, p.455). This was an unexpected find in the study, and the authors concluded that ‘These findings contradict the view that boys are a homogeneous group, who have a more positive attitude towards physics than girls' (Osborne and Collins, 2001, p.455).

When discussing aspects of physics that the pupils found interesting, a definite gender difference occurred in that girls preferred the study of light and electricity and boys preferred forces, cars and flight. However the topic of 'space' emerged as a clear favourite with all pupils, whether they were girls or boys, continuing with science or not. This led Osborne and Collins to conclude that: 'the universal success of this topic should not be underestimated as a valuable point of engagement with science' (Osborne and Collins, 2001, p.457).

Throughout this study, there were concerns that pupils were making comments about individual teachers, which was beyond the scope of their research: 'The importance of the role played by teachers in stimulating and maintaining pupils' interest in science was raised unprompted by pupils in every group' (Osborne and Collins, 2001, p.459). The report states that 'attempts were made during the discussions to limit pupils' comments about individual teachers, as this was not the focus of the research' (Osborne and Collins, 2001, p.459).

Pupils in all groups identified that teachers made the subject appealing to them and made lessons interesting. Most of the comments showed that pupils like teachers who maintain order, make learning interesting by using a range of activities, as well as keeping an atmosphere of 'mutual good humour'. The research conducted by Osborne and Collins, whilst striving to focus upon scientific topics, could not avoid finding that one of the most important factors in physics education was the enthusiasm of a good teacher. These findings, however, are not confined to physics, as they corroborate the work of Kyriacou (2009), Petty (2009) and Cooper (2011), which relate to teachers of all disciplines.

Reid and Skryabina conducted research in Scotland and contrasted attitudes towards physics in Scotland with those in England and Wales (Reid and Skryabina, 2002, pp.67-81). A larger proportion of young people take physics as a higher subject than those who follow the A level route in England and Wales. Reid and Skryabina explain that: 'In England, physics is perceived as rather an elite subject, which is viewed as conceptually very difficult and only suitable for exceptionally able students' contrasting this to the attitude in Scotland that physics is: 'perceived as a rather ordinary school subject which is open to a large number of pupils'. They believe that the reason for this is due to the 'application-led' Standard Grade examinations (equivalent to GCSEs) which were introduced in Scotland in 1989, replacing the former Ordinary Standard examinations. They conducted research into attitudes towards physics by conducting a survey of 850 school pupils and 208 university students, ranging in age from 10 to 20 years. The research was conducted by questionnaires and interviews, to provide a series of 'snap shots' of attitudes held by young people at different stages of their education.

From the research, Reid and Skryabina found that there were two 'declines' in attitudes towards science/physics, the first being after the pupils have moved from primary to secondary school, and the second being after the transition from Standard to Higher Grade. Because the Standard Grade is so popular, 55% of Standard Grade students go on to study the Higher

Grade and 11% of the Higher Grade students proceed to study physics at university (Reid and Skryabina, 2002, p.74).

Attitudes of the physics undergraduate students were extremely positive. When the university students were asked what had been the main influence upon their choice, 87% said that it was due to enjoyment of the subject at school, 74% said that it was due to achieving good grades at school in this subject, 49% said that it was due to strong career prospects and 27% indicated that it was due to their teacher at school. The low score for the 'teacher effect' seems surprising, particularly as other research indicates the importance of good physics teaching (see section 3.2.2 of this chapter).

In the evaluation, it was noticed that two factors were extremely significant: the quality of the course (teaching and curriculum) and potential career opportunities for the future. Within this research, however, there was a complete absence of the wider factors such as parents, peers, media or external initiatives. The survey of physics undergraduates within this study did not mention the gender representation of the sample, which may have provided an interesting comparison of data.

Hoffmann (2002) conducted an intervention project with first year secondary pupils in Germany. The project was specifically aimed at 'giving the girls a better chance in science' and involved the development of new teaching materials and monitoring of teacher behaviour. Hoffmann produced a questionnaire with 88 items which combined eight areas of physics with seven different contexts and four groups of activities. It was found that girls find physics less interesting as they grow older and they placed a higher importance on ‘references to mankind, social involvement, and the practical applications of theoretical concepts’ (Hoffmann, 2002, p.450). It was also found that girls receive less support from their parents to work in physics or technology than boys, who were actively encouraged to develop careers in these areas.

Research into the problem of girls and physics was conducted in Israel, where the ratio of girls to boys in advanced physics classes is 1:3 (Zohar and Bronshtein**,** 2005, pp.61-67). They stated that it was rare for advanced physics to be taught in schools with a high number of students from low social economic class backgrounds. For their investigation, they conducted a study with 25 physics teachers (16 male and 9 female) from 25 different high schools in Israel. They found that most of the teachers who participated in the study expressed ‘indifference and lack of knowledge regarding girls’ low participation in advanced physics classes’ and two thirds of the teachers did not see the gender gap as being a problem. This may be a reflection of different cultural attitudes towards education, as the most significant research into girls and physics has been conducted in Europe, the USA and Australia.

In summary, there is a need for teachers to be aware of any gender differences that may exist within the classroom, but as Murphy and Whitelegg point out: ‘There is significant evidence that a context based or humanistic curriculum increases students’ motivation and enjoyment of physics, especially for girls…the teacher, however, is critical’ (Murphy and Whitelegg, 2006, p.20).

3.2.2 The importance of good teaching in physics

The importance of good teaching is a subject which has generated a vast amount of literature in all academic and vocational disciplines. For this section, however, I shall restrict the discussion to the literature that relates directly towards the teaching of physics. Murphy and Whitelegg (2006) claim that there have not been any recent UK empirical studies (1995 to 2005) into the effect of physics teachers, so in their report they drew upon work that had been conducted in other countries or earlier UK research. For example, in a Canadian study, Haggerty found that male science teachers had a more didactic style of teaching whilst female science teachers developed a better relationship with students. They also suggested that female teachers, on average, adopted a range of teaching styles and were better at connecting with students (Murphy and Whitelegg, 2006, p.25).

Krogh and Thomsen conducted an investigation into Danish students' attitudes towards science, and found that personal teacher support was one of the most important factors for students' attitudes and choice of A level subjects (Krogh and Thomsen 2005, p.298). 789 students were given a questionnaire with 80 items in order to evaluate the factors that influenced their choice of subjects. They state that: 'The marked need for students to have teachers respond to them personally may reflect structure-related changes of youth identities in a post-modern society' (Krogh and Thomsen 2005, p.298). They suggest that physics teachers show more interest in students as individuals and allow themselves to 'being more off task' in the classroom. One interesting point that emerged was that the students believed laboratory work was only to confirm laws and theories and that there were no ‘degrees of freedom for inquiry’ (Krogh and Thomsen, 2005, p.287).

Zohar and Bronshtein’s investigation, which was conducted in Israel, found that the teachers’ attitudes towards girls and physics were an issue (Zohar and Bronshtein, 2005, pp.61-77). Some of the teachers believed girls anticipate their future role as mothers and study subjects that are more appropriate for this role. Some of the teachers believed that the low participation of girls was due to the fact that girls had a ‘lower ability to solve problems’ than boys. Interestingly, it emerged from this investigation that immigrants from the Soviet Union, which consisted of almost 20% of the population, were much more aware of the importance of physics than other ethnic groups in Israel. This suggests that attitudes towards physics could have cultural differences.

A different type of research that can be mentioned under the heading of good teaching, are the Action Research Projects that encourage practising physics teachers to reflect upon their own practice and consider ways in which individual teachers can make small changes that can ultimately make a difference.

An Action Research Project into Physics Education (Daly, Grant and Bultitude, 2008) collated the findings from projects conducted by physics teachers in 2008, which was a predecessor to the Action Research Project that I participated in during 2009/2010. Some of the projects, which were conducted in schools by ordinary classroom teachers, included working with gender neutral illustrations, using non-technical language and linking topics with applications and social relevance (Daly, Grant and Bultitude, 2008, p.19).

The teachers found that using gender specific examples did not make any difference to the pupils and that ‘girls respond better to the real life situation rather than conceptual process’ (Daly, Grant and Bultitude, 2008, p.20). The project which explored the teaching of physics through non-technical language found that developing good starter activities made both the girls and boys more interested in the subject of the lesson and suggested the creation of a bank of useful and imaginative ways of starting lessons (Daly, Grant and Bultitude, 2008, p.20). The third project involved working with other disciplines and the participants found that by incorporating drama and careers education into physics lessons improved the engagement of the pupils. The teachers concluded at the end of the project that ‘using and researching teaching and learning strategies to make physics specifically more accessible to girls doesn’t have a detrimental effect on boys’ interests and achievement, but is in fact good teaching practice’ (Daly, Grant and Bultitude, 2008, p.23).

Murphy and Whitelegg claim: ‘There is some evidence that science teachers show less leadership, friendliness or understanding towards students than teachers of other subjects, and their relationships with students are poorer than relationships in humanities subjects’ (Murphy and Whitelegg, 2006, p.24). In section 3.3.1 of this chapter, there is reference to the ‘emotional reticence’ of students who are attracted towards science at school. The flaws of science teachers outlined above could be a direct extrapolation of the personalities of students drawn to science. It must be stated that these are generalisations, and clearly not true for all students or teachers of science. What Murphy and Whitelegg indicate is a lack of empathy shown by the teachers, and this important quality is discussed later in this chapter.

Some important factors for a physics teacher to consider are:

- A variety of teaching and learning strategies to enhance and maintain engagement with the subject.
- Regular monitoring of teacher-student interactions to ensure girls are participating in lessons as much as boys.
- Positive feedback and encouragement from teachers during lessons and in personal conversations, as well as a respect for students' learning needs are crucial.

(Murphy and Whitelegg, 2006, p.28)

The importance of good teaching cannot be stressed too highly, and whilst the literature cited above relates directly to physics teaching, the concepts can be extrapolated to all subject disciplines.

3.2.3 Physics as a difficult subject

There are many factors that affect research into this subject and make comparisons between subject disciplines difficult. This is due to all of the other variables, such as size of classes and the way in which different subjects are taught. Fitz-Gibbon's study into 'Long-term Consequences of Curriculum Choices, with particular reference to Mathematics and Science' expressed concern that choices of A level subjects were made with little evidence regarding the consequences of these decisions. She claimed that: 'What is taught may be of more consequence than how effectively it is taught' and expresses concern that schools are more interested in performance tables, hence higher grades, than subject choice (Fitz-Gibbon, 1999, p.218).

In this study, Fitz-Gibbon found that maths and science subjects were between half and one grade more difficult than all other subjects (apart from foreign languages), and suggests that this may discourage schools and colleges from advising students to enrol in 'difficult subjects' (Fitz-Gibbon, 1999, p.220). She questions whether it is ethical for teachers and careers officers to 'encourage' students to study mathematics and science if their grades are likely to be less than if they studied other subjects (Fitz-Gibbon, 1999, p.219).

Fitz-Gibbon studied the 'pulling power' of mathematics departments, named to classify those departments who actively encouraged students to study mathematics, compared to those who did not. She found that after a five year study, the quality of life and salaries for those who studied mathematics in high 'pulling power' institutions were higher than those of students who studied in low 'pulling power' institutions and had chosen other A level subjects instead. It was stated that the departments with greater pulling power may be more effective at teaching these subjects, however this report was not concerned with quality of teaching, but rather the encouragement or possible discouragement of subject choice (Fitz-Gibbon, 1999, p.230).

The study by Elwood and Comber (1996) was funded by the Nuffield Foundation to explore gender differences in examinations at the age of 18. The study involved questionnaires to heads of department, case studies, and the analysis of 3000 examination scripts for three main subjects: English Literature, Mathematics and Physics. The main findings of this report were that teachers believed, in general, that male students were more confident than female students, and teachers seemed to think that girls lacked flair or sparkle compared with male students

Murphy and Whitelegg summarised some of the findings from the research and stated that: ‘generally across subjects, males tended to attribute success to their own efforts and failure to external factors. Females, however, did the converse.’ (Murphy and Whitelegg, 2006, p.39) They claim that comparing the difficulty of different subjects is questionable, but ‘it is generally agreed that physics is a difficult subject’. For students who want to achieve the best grade possible from their A levels, physics may not be the best choice and this may deter some students from the study of physics at A level. League table considerations may put pressure on teachers to advise those students of moderate ability to consider other options. This may have an impact on the number of girls who study physics at A level.

Aside from the academic literature, the practical application of this perception of difficulty is manifested in the literature provided by the most prestigious independent school in the region:

> ‘Past history, however, has shown us that, in particular, Maths and the three sciences are less accessible for those who have lower than an A grade at GCSE, and even those with low A grades can find these subjects a struggle...What you will notice is that those

> with a B or less struggled to achieve anything more than a C at AS, and then even less at A level. We would encourage you to think very carefully about this when making your choices. These tend to be sequential subjects and once you get behind with the understanding it becomes more and more difficult’
>
> (Royal Grammar School, Newcastle, Sixth Form guide, 2011)

Clearly, the purpose of this information for prospective students and their parents is to ensure an awareness of the difficulty of these subjects. For students in the state sector, particularly in the FEC, the perception of difficulty may deter some students from pursuing physics.

3.2.4 Methods of assessment

This section explores the research that has been conducted into gender performance in Physics examinations, as well as the impact of assessment techniques.

In 1978, there were 40,000 girls who studied physics to CSE or O level, compared to 167,000 boys (in England). By 1988, there were 63,500 girls who studied physics compared to 158,000 boys. It is debatable whether the interventions from 1978 to 1988 accounted for the increase in the uptake of physics by girls (Murphy and Whitelegg, 2006, p.41). The National Curriculum was introduced in 1988 which meant that all school pupils had to study science up to age 16, whether as a single award GCSE, Double award, or triple science (three separate sciences).

By 2000, there were 18,338 girls and 28,289 boys entered for GCSE physics. At first glance, these figures appear to be considerably less than the corresponding numbers for 1978. The main reason for this is due to the greater number of students who study the Double Award Science Course. It does seem, however, that specialist physics knowledge for sixteen year olds decreased markedly since 1978. According to JCQ the numbers for physics GCSE have increased since 2000 with 120,455 candidates for GCSE physics in 2010, of which 53,933 (44.8%) were girls (JCQ, 2010).

When analysing data for the Double Award Science courses, there is some evidence to suggest that boys perform better at the physics component, although the students are not given separate marks for each topic. Whilst the examination results indicate that more girls gain A or B grades than boys (Murphy and Whitelegg, 2006, p.42), this may be due to their performance in the biology or chemistry components of the examination. On the other hand, without any clear data to analyse, it could simply be a consequence of the pupils' perception.

In 1982, Murphy investigated all of the subject papers for one examination board and found that the performance of boys increased when multiple-choice tests replaced written tests. Murphy also found that girls outperformed boys on structured questions and claimed that with multiple-choice tests, boys were prepared to guess, whereas girls were less likely to take risks if they were not sure of the answer (Murphy and Whitelegg, 2006, p.46). It was found that girls thought about the context of the question more than boys and any ambiguities about the context led to confusion (Gipps and Murphy, 1994).

There is evidence to suggest that the format of the questions can influence achievement. Boaler conducted a small-scale study into the contexts of questions in mathematics and found that this can be more problematic for girls. She claimed that some of the attempts to contextualise mathematical problems created artificial situations, which she described as ‘pseudo-real contexts’. These were more confusing for girls and could potentially lead to disinterest in mathematics (Boaler, 1994, p.555). The findings of this study can be applied towards physics examinations, where some of the questions are framed in contexts which require a lot of reading and assimilation by pupils. Although the specifications clearly state that examiners will design questions in new or unfamiliar contexts, this seems to present problems for both male and female students.

Whilst Boaler’s research was conducted within the field of mathematics, she compares the way that the subject is assessed compared to other subjects such as English. In mathematics, the answers are either correct or incorrect, whereas in English, there were areas open to interpretation. It was suggested that this was an important factor for weaker students in particular, as there is no scope for negotiation in maths (Boaler, 1994, p.554).

Elwood and Comber (1996) studied gender differences in examinations and investigated four components of an A level physics paper: multiple choice paper (25%), short and long response paper (35%), passage analysis and selected topics paper (20%) and finally a practical paper (20%). It was found from this research that the first two papers contributed more to the overall marks of the students (both boys and girls) than the other two papers. The girls fared better than the boys in the last two papers, although this was not sufficient to detect any gender differences.

Research by Quinlan (1990) found a direct relationship between the improvement of girls' GCSE grades between 1985 and 1988 with the weighting of coursework. However, it was later shown that because the coursework marks showed little variation in the spread of marks, they did not contribute significantly towards the final grade in the subject. The research on this topic found that whilst girls, considered as a group, achieve higher marks for coursework than boys, it does not necessarily mean that girls are advantaged by this form of assessment (Murphy and Whitelegg, 2006, p.49).

Murphy and Whitelegg could not find any research on gender and the effect of modular assessment at Key Stage 4 in science. There has been some small-scale research into modular physics A level (McClune, 2001, pp.79-89). The sample of students was large but the number of questions was small. It was found that year 13 students outperformed year 12 students on the same questions. The findings could explain that the year 13 students had consolidated their understanding compared to younger students. It was also pointed out that this could be due to an increase in maturity or experience at answering test questions.

McClune stated that there is some evidence suggesting that boys, rather than girls, are more likely to take advantage of the some of the features of modular A levels. The report does, however, stress the limitations of the study and encourage further research into modular A levels. This research is of particular interest to my study (Section 4 of the portfolio), as the data from the FEC also suggests that boys take, in general, more re-sits than girls and that high first year marks are combined with weaker second year marks to produce the final grade. This could be due to maturity, as

McClune states, but is perhaps more strongly associated with his suggestion of greater consolidation of the topics.

Murphy and Whitelegg's report states that there has been little research into other subgroups such as race or class, but strongly urge that more research is undertaken with assessment and examination of students in physics. They suggest that teachers use examination results in order to review classroom practice and understand that the format of questions can have a significant effect upon student performance (Murphy and Whitelegg, 2006, p.51).

3.3 Educational influences outside of the classroom

There are several factors that influence students' educational progress that lie outside of the control of the classroom practitioner. Some of these factors are the nature or ethos of the establishment, the family background (which is strongly linked to social class) and the wider influences of society such as culture and the media. One of the most important factors, however, is how students perceive physics as being relevant to their lives outside of the classroom, and whether physics is relevant to their future career. This section of the report will explore:

Physics as a relevant subject	(3.3.1)
The ethos of the educational establishment	(3.3.2)
The importance of family background	(3.3.3)
Representations of scientists and role models	(3.3.4)

3.3.1 Physics as a relevant subject

Within physics based research, it is usually stressed that young people rarely use the word ‘relevance’, however this is a significant factor that motivates students’ decisions. In the context of this study, ‘relevance’ relates to how meaningful the students perceive the subject to be with respect to their own lives. Under the issue of relevance, gender issues are very important, but not exclusive to the discussion.

The introduction of the National Curriculum in Science (England and Wales, 1988) ensured access to science courses for both girls and boys, ensuring that all pupils studied some form of science up to the age of sixteen. There is some research, however, which claims that the perception and relevance of science education is influenced at a far earlier stage of child development than secondary school, with attitudes (of the boys, as well as girls) formed at the nursery stage of education.

Murphy (1997) conducted a case study of pre-school children, finding that girls’ play was generally influenced by maternal, nurturing behaviour. In role play, it was found that the most popular role chosen by girls was to pretend to be ‘a princess’. Boys were, in general more physically active in their play and if they did engage in role play, it was usually as a policeman, fire fighter or a superhero. Murphy concluded that girls prefer creative play, whereas boys prefer more constructive activities. Murphy believed that play in the pre-school years led to different ways of seeing the world as well as interacting with it. This study also showed that young children noticed different aspects of their environment, as well as influencing the language development associated with the chosen form of play activity (Murphy, 1997).

Whitelegg discussed the differences in how young children play, claiming that when children aged between 5 and 6 were playing with Lego, the boys appeared to have ‘superior construction skills’ whereas the girls models were much simpler in design. Whitelegg concludes that children, as well as teachers, bring the effects of socialisation with them into the classroom and this affects how they interact with each other, the subjects and the resources available (Whitelegg, 1992, p.180). Clearly there are many other influences upon pre-school children and toys are only one factor. Whilst I do not believe that toys and play are the sole factors in developing attitudes towards science, I find it very frustrating that even in the twenty first century, the largest toy retailer in the UK promotes toys for boys and girls within quite distinct and separate aisles, with the aisles for girls’ toys decorated in pink and other pastel colours.

Kelly (1987) was not convinced that differences in spatial ability were the reasons that girls do not take up science. She believes that it is partly due to the way in which children are brought up, where masculinity is associated with independence, self-reliance, strength and leadership, whereas femininity is associated with conformity, passivity and concern for other people (Kelly, 1987, p.13). Kelly concluded that girls’ lack of self-confidence, the masculine image of science and the impersonal approach were probably the main reasons why the subject failed to attract girls. Kelly makes the valid point that biological reasons cannot be the sole reason for the under-representation of women in science, since women in Eastern Europe are well represented in science (Kelly, 1987, p.13).

Whilst this section is specifically concerned with how young children develop attitudes towards science, many of the great educationalists have studied the importance of play in child development. Both Piaget and Vygotsky believed that considerable learning is taking place when children play. Through the use of language, children can share ideas about objects, roles and ideas, According to Mooney: ‘Vygotsky’s primary contribution to our understanding of young children’s development is his understanding of the importance of interaction with teachers and peers in advancing children’s knowledge’ (Mooney, 2000, p.83).

An essay by Head in the same text explored the personalities of those who chose to study science at school:

> ‘For boys.... physical sciences in particular offer a conventional career choice which is likely to win approval from parents, teachers and peers. They will tend to regard the overt expressions of emotions as being soft and feminine. Science with its masculine image, makes little emotional demand on an individual and seems to offer clear, precise answers to problems. Opting for science will permit and possibly reinforce emotional reticence.’
>
> (Head, 1987, p.21)

Head claimed that girls are socialised into more feminine roles of mother and housewife rather than developing their own careers. This was interesting, as it makes reference to ‘emotional reticence’ of those people attracted towards science. Within the portfolio (Section 1), there is discussion of the focus group with students from the FEC who chose not to study physics A level and whilst they did not use these precise words, they indicated that physics teachers at their schools lacked empathy and interpersonal skills.

In ‘Has Feminism changed Science?’ (1999), Schiebinger claims that when the talking version of the Barbie doll was introduced (1992), the first words that the doll uttered were ‘Math class is tough’ (Schiebinger, 1999, p.67). Apparently there were a number of protests from women’s groups and the phrase was then removed from the doll’s ‘repertoire of ready phrases’. Schiebinger’s refers to the ‘Barbie Debate’ on the internet, and whilst the particular reference quoted in the text was no longer active, there were several contemporary forums which discussed the negative (or occasionally positive) effects that this doll could have on young girls. Schiebinger points out that ‘giving girls and boys different toys may be harmless except for the fact that toys create aspirations, hone conceptual skills, and encourage certain behaviours to the exclusion of others’ (Schiebinger, 1999, p.55). In her essay ‘Barbie and Action Man’, Attfield argues that ‘toys cannot fully determine actions or thoughts’ and that it is how the children play with the toys that is more important (Attfield, 1996).

Jane Gilbert argued that: ‘much of the published research on gender and science education reproduces, rather than solves, the problem’. She claimed that the early initiatives and intervention programmes focussed upon changing girls to be more like boys. In order to make science more enjoyable for girls, Gilbert proposed that science should be taught in order to educate young people about science but not focussed upon training them to be scientists (Gilbert, 2001, pp.291 -305).

Whilst it is important to promote physics as a relevant subject for girls and actively engage girls with the subject, it is crucial that assumptions are not made which are patronising or, in fact, insulting to young people. Jones and Kirk investigated pupils' interest in learning about different topics in physics and found that neither girls nor boys were particularly interested in learning about how domestic appliances work (Jones and Kirk, 1990, p.312). From a list of thirty possible topics, the five least favourite topics for girls were the same as the least favourite for boys (vacuum cleaners, forces on moving objects, bicycle pumps, kinetic energy and kiln temperature). They found that girls were interested in exploring the medical applications of physics and aspects of the subject that involve people.

To summarise, research suggests that attitudes towards science are developed at an early age, although it must be stressed that any generalisations about gender can be misleading. It is also clear that influences outside of the classroom can shape attitudes towards science that can be very difficult for a classroom teacher to overcome. Teachers must try to show the relevance of science (or physics in particular) to all students. It has been suggested that a more humanistic approach to physics may enhance student interest and motivation.

3.3.2 The ethos of the educational establishment

Within the context of physics education, the ethos of the establishment can be considered in two ways, firstly the differences between state and independent education, then secondly whether the school is mixed or single sex.

JCQ provides data on the proportion of candidates from different educational backgrounds. Using the statistics available, it is clear that there are some subjects which have a greater proportion of candidates from independent schools than others. For example, in 2010, 20.3% of the candidates for physics A level were from independent schools (chemistry 18.2%, biology 15.2%) whereas other subjects have a smaller proportion of candidates from the independent sector (for example, law 1%, sociology 1.5% and media studies 2.3%). Whilst one could assume that this could simply be a reflection of the size of the cohort, it is not as there was approximately half the number of candidates for A level law (15,000) as physics (31,000) (JCQ, 2011). The data clearly suggests that some academic subjects are more popular in independent schools than state schools, and vice versa (for example, foreign languages are also more popular in the independent schools than in the state sector).

The websites of two independent schools have been used to compare the educational opportunities provided by the FEC with the independent sector. These are the Grange School in Cheshire and the Royal Grammar School in Newcastle-Upon-Tyne. One of the most striking differences between the FEC and these two schools is the ethos of the establishment, with independent schools promoting clear scholarly values. Whilst there are strong similarities in the same Examination Board studied and the number of hours per week for each A level science subject, there are some differences such as the size of classes and extra-curricular opportunities on offer. The uniform or dress code of an independent school conveys a visual image of the expectations of the school, whereas the casual attire worn by students at a FEC may suggest a lack of formality or discipline. These, however, are relatively minor issues compared with the wider factors such as social class and the expectations of the family.

Clegg, in an essay ‘Acknowledging Disadvantages’ provides a long list of the differences between children in ‘grey areas of the country’ and those from more privileged backgrounds. He claims that these impediments lead to a lack of security, confidence and achievement of children from lower working class backgrounds. Clegg suggests that educational opportunities are also linked with the different environments associated with social class: ‘It is curious that for so long we have failed to assess the full impact of environment’ (Clegg, 1994, p.71). He makes an interesting analogy of the mild yield of cows from scrub land or rich pastures to illustrate the importance of educational environment.

Noddings, in *Happiness and Education* discusses the fact that there is a class divide in United States mathematics achievement: ‘If rich kids have been able to pass these courses, why can’t poor kids?’ (Noddings, 2003, p.201) She claims there is ‘an attitude’ which implies the under-achievement of the ‘poor kids’ is the fault of the school, but then explains that the ‘rich kids’ have various other factors in their favour such as educated parents who can empathise with the learning, encouragement to work hard at school and complete homework, as well as tutors for individual support.

At this point, it may be necessary to explain the political background of FECs. Unlike schools, colleges are not controlled by the Local Authority, but are ‘incorporated businesses’. They are managed and operated as independent institutions to deliver courses in the most cost-effective manner, yet imposing constant pressure on teachers to raise standards. The FE sector of education is the largest provider of education for 16 to 18 year olds, with 3.5 million learners enrolled at over 250 FECs in the UK and its student body includes a greater than average proportion of students from deprived backgrounds, ethnic minorities and female students (Hayes, Marshall and Turner, 2007, p.7).

Hayes, Marshall and Turner further explain that the current political framework of further education is vulnerable to 'Quango Capture' where different government agencies shape the decisions made by the senior management of each college. They cynically suggest that managers play a game of 'hunt the funding stream' and that:

> 'This is a life dominated by quixotic, fast moving, internally imposed and often, poorly rationalised decisions. Consequently, senior and middle managers, who often try to remain upright on the shifting sands of a policy desert, can often exhibit a brittle and sometimes aloof approach to their staff'.
>
> (Hayes, Marshall and Turner, 2007, p. 9)

Whilst this background may be appear to be outside of the scope of a study into physics education, it is important to understand the political framework that shapes the experience of the students, as well as the teachers who work in the ever-changing world of further education. For young people in this city, the FEC is the only provider of post-compulsory education, unless opting for a faith or independent school.

Bryan and Hayes, in an essay entitled 'The McDonaldisation of Further Education' suggest that FECs are striving to emulate the business approach of fast food chains. Whilst not denigrating the McDonald's corporation, as they claim that this company presents efficient, reliable, comfortable and consistent service, as well as making a huge profit, they argue that the means to achieving this is for the company to be tightly controlled, predictable and with an over-arching corporate identity. They claim that investment in ‘customer service’ roles and the emergence of ‘welcoming’ and attractive features contribute towards this image (Hayes, Marshall and Turner, 2007, p.51).

I found this particularly interesting as I have been intrigued by the design of the two new sixth forms within the FEC, both of which present a very informal learning environment. The new buildings were specifically designed with the intention of attracting, recruiting and retaining students. One of the Sixth Form Centres was designed to have a central street within the building, landscaped by trees with a cafe ‘where staff and students can meet and socialise’ (Dewjo’c Architects, 2010). I find this important to mention as I believe the political background influences the architecture of the builidings, which then creates the learning environment and consequently the ethos of the institution.

Bryan and Hayes extend their McDonald’s comparison by suggesting that: ‘McLecturers teach the same lessons year after year with formulaic objectives - all lessons are alike. Timings within each lesson planned and structured, course handbooks outline lesson by lesson objectives. The McManager’s job consists of administrative tasks and completing proforma documents, which are often online and controlled by various quality monitoring departments’ (Hayes et al, 2007, p.52). I would agree that over the past ten years, the college has been tightly managed to control all aspects of the corporation. The constant monitoring of quality by peer observations, line manager observations and internal inspectors ensures that all teachers develop the same approach to teaching and learning, and the amount of administration has become over-whelming.

Cooper (2011) discusses the fact that little research has been conducted into Further Education, which ‘has always been the poor relation’ (Cooper, 2011, p.195). She makes reference to the fact that teachers in FECs have lower pay than teachers in schools and colleges have more of a managerial approach to both staff and students. Cooper discusses the fact that many students in Further Education have low self-esteem and that whilst teachers are aware of the need for empathy, emotion and relationships to learning, ‘the whole area seems to be very underplayed in much academic research’ (Cooper, 2011, p.197). I would heartily agree with this statement and believe that Further Education is operated too much as a business, rather than considering the education for the community.

Whilst the issue of single sex schooling directly contributes towards the educational processes within the classroom, it is generally beyond the control of the teacher. Murphy and Whitelegg claim there have been ‘numerous studies’ exploring the effect of single sex schools on educational performance, however most of the research has been generic rather than subject based (Murphy and Whitelegg, 2006, p.29). In one study (Smithers and Robinson, 1995), an evaluation of the 1994 examination results suggested that the high level of achievement in single sex schools was due to the nature and ethos of the schools, rather than the segregation of the sexes. This was due to the fact that (in the cohort studied) the single sex schools were selective, recruited from higher socio-economic backgrounds and held long established academic traditions.

The issue of school ethos is an interesting factor, which may initially appear to be outside of the scope of this study. The ethos of an educational establishment is carefully structured and planned to reflect the students which it seeks to attract. The FEC seeks to attract a wide range of students of all abilities, therefore presents a different environment to that of a school. Section 7 of the portfolio explores the ethos of the FEC in more detail as the selection of educational establishment directly influences the subjects available and the attitudes towards learning.

3.3.3 The importance of family background

It has proved difficult to find literature which directly relates science education with family background, so my reading extended to cover more generic studies. The importance of family must not be underestimated and this factor is inherent in many of the studies contained within the portfolio. Whether the influence of the family was manifested in the decision to study at the FEC (within the city, the choice is limited to the FEC, faith school sixth forms or an independent school) or in choice of university, or future career, family plays an important role in the decisions made by young people.

According to Hargreaves, the parents are a child's primary source of knowledge, beliefs and values. As a child develops, it constructs a 'reality' based upon the parents' expectations and attitudes. As the child grows older, it interacts with other 'significant others' such as teachers, friends and groups, yet the first primary influence are the parents who 'channel and filter the culture to the child in their interactions with him' (Hargreaves, 1972, p.9). Whilst this study is concerned with studies in post-compulsory education, it is important to realise that many of the attitudes of young people have been created earlier in life, and that students 'absorb' values from their parents.

In another study by Hargreaves, he investigated a secondary modern school for boys in an unspecified town in the north of England. One of the main conclusions of the study was 'to affirm the fundamental importance of the social system of a school, and especially the importance of peer groups in relation to the educative process' (Hargreaves, 1967, p.182). He claimed that it was common practice for the teachers to blame family background or home environment for the child's attitudes, yet the importance of 'age-mates' within the same stream put pressure on the pupils to conform. He claimed that 'personality is not static but a dynamic and changing process to which peer group membership may make a fundamental contribution' (Hargreaves, 1967, p.183). Although this is a relatively dated study, it proposes that peer pressure from classmates can be a very powerful influence.

If this is extended to my particular study, it can be seen that whilst family background is an important factor, the pupils or students within an institution can provide another more formative sphere of influence. The secondary schools which our current students attended may have played a part in shaping their attitudes, including peer groups within those schools. It may be an area for further study to determine the influence of peer groups within a FEC, as I expect this to be less of an influence than the peer groups of their secondary schools.

Desforges conducted a review of parental involvement and found that the ‘extent and form of parental involvement is strongly influenced by family social class, maternal level of education, material deprivation, maternal psycho-social health, single parent status and to a lesser degree, family ethnicity’ (DfES, 2003, p.4). The report also claimed that the extent to which parents were involved in the child’s education was determined by how well the child was achieving at school.

A paper by Reay and Ball: ‘Making their minds up: family dynamics of school choice’ stated that middle class parents guide their child into making the ‘best choice’ of school, while many working class families ‘defer to the child’s judgement’ (Reay and Ball, 1998, p.431). Working class decisions are made upon which establishment is nearest and where friends are going, whereas for middle class families, localism is not as important. This was borne out in one of my studies contained within the portfolio (Section 7 – Physics Education: influences outside of the classroom).

Another paper by Reay: ‘Choices of Degree or Degree of Choice’ provided strong corroboration for my investigations into choice of degree subject for students at the FEC (Sections 2, 7 and 8 of the portfolio). This paper explored the fact that working class students are entering different universities to middle class students. The report discusses the strata of universities and the fact that the more prestigious universities ‘remain overwhelmingly white and middle class’ (Reay et al., 2001, p.858). Working class students tend to choose universities that are local, often to keep part time jobs while studying. This report was particularly interesting as it suggested that the reasons for working class students choosing to remain local were not always financial, but there were ‘suggestions of emotional constraints on choice’ (Reay et al., 2001, p.863). This latter factor included worries about ‘fitting in’ or ‘feeling safe’, which were not factors that featured in the middle class responses. This study was particularly relevant to the study in my portfolio (Section 8), where I found very few students from the FEC were prepared to move away from home in order to study for a degree course.

The issue of gender and parental involvement was explored by David et al. who claimed that ‘gender is threaded throughout the process of choosing higher education’ (David et al. 2003, p.21). They found that gender affected all aspects of the research, from those who volunteered to participate in the survey (more girls), which parent was chosen to participate and the difference in the involvement of the mothers and fathers. *Higher Education and Social Class* (Archer, 2003) provided a useful reference text to explore the different choices available to young people based upon their social class.

Brooks (2004) conducted a small scale investigation into parental involvement in higher education choices (‘My mum would be as pleased as punch if I actually went, but my dad is a bit more particular about it’). The methodology was mainly interviews, determining the social background of a small group of students then asking questions about the decision making process of selecting a university. Brooks found that few of the families had exercised any form of choice for primary, secondary or sixth form, with all students attending the most local provider of education. Brooks claimed that within metropolitan areas, the middle classes were ‘active choosers’ within educational markets and suggested that research in other areas may provide a different picture (Brooks, 2004, p.507). This investigation was used as a basis for my research into parental involvement (Section 7 of the portfolio).

The issue of student choice in the selection of degree courses was further explored by Reay in *Degrees of Choice: Social Class, Race and Gender in Higher Education* (2005), particularly the invisible restrictions imposed upon working class students by their family commitments as well as financial constraints.

Evans (2009) suggested that working class girls chose to study at local universities so they could live at home and fulfil family commitments: 'for many working class girls, entry into HE is structured by family ties and loyalties' (Evans, 2009, p.342). This is particularly applicable to students from the FEC who choose to study at the local university, despite many of them achieving high grades and therefore having the potential to progress to Russell Group universities.

In Section 10 of the portfolio, there is a case study of the only girl (from the FEC) who has proceeded to study physics at university in the last ten years. This student came from a middle class family, where education was an expectation not an aspiration.

3.3.4 Representations of scientists and role models

The UK Research Centre for Women (UKRC) provided a range of literature that provided a starting point for my studies within this section. 'The (In)visible Witness Project' states that: 'It can be argued that consistently gendered mass mediated portrayals of STEM may partly influence how children and young people perceive STEM, alongside whether a STEM-related career is attractive and achievable' (Whitelegg et al., 2008, p.2). The report provides an analysis of the coverage of STEM on UK television and an investigation into children's perception of STEM, largely drawing upon work conducted by Mead and Metraux (1957).

The study by Mead and Metraux,: 'The image of the Scientist among High School Students' (1957) is quite dated yet widely cited in subsequent literature. For this study, children were asked to write about scientists and after analysing the data, the authors produced the following synopsis:

> 'The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses...He may wear a beard, may be unshaven and unkempt. He may be stooped and tired.'
>
> (Mead and Metraux, 1957, p.387)

The study was significant in that it showed that at very early ages, children had perceptions of stereotypes, and that there was a clear identification of science as a male dominated profession. The study made several recommendations, one of which was the responsibility of the mass media:

> 'What is needed in the mass media is more emphasis on the real, human rewards of science – on the way in which scientists today work in groups, share common problems and are neither 'cogs in a machine' nor 'lonely' and 'isolated.'
>
> (Mead and Metraux, 1957, p.389)

Sir Christopher Frayling outlines the perceptions of scientists in his very enjoyable text: *Mad, Bad and Dangerous: The Scientist and the Cinema.* He reported a more recent adaptation of the 'Draw a Scientist' exercise, where 4,807 school children participated in the study (2,000 girls) yet only 28 women were drawn. Frayling expressed concern that over the period of time since Mead and Metraux's original investigation, the stereotypical view of a scientist remained (Frayling, 2005, p.14).

Another useful study from the UKRC was: 'Role Models in the Media: An exploration of the views and experiences of women in Science, Engineering and Technology'. The report began by outlining the problems in attracting women to STEM subjects, quoting physics as a subject of particular concern (Kitzinger et al., 2008, p.1). For this study, the views of 86 women who currently work in STEM–related careers were sought, then a series of focus groups were held to determine the views in more detail. The report states: 'The media were criticised for sometimes presenting women in SET as socially incompetent, victimised and somehow de-feminised' (Kitzinger et al., 2008, p.16). The recommendations of this report were that there should be more diverse representations of women scientists in the media, as well as more science television programmes for young people.

This report introduced me to the importance of role models, for whilst I had long believed the media to be an important influence upon the choices made by young people, I had not quite appreciated the concept of role model theory. Applying this to my studies, it became immediately clear why the most popular degree course for girls who studied science A levels at the FEC was pharmacy, as most young people have an image of a pharmacist, for which many girls could project an image of their future selves. The vast majority of students at the FEC have never met a ‘scientist’ nor have any understanding of what such a profession would involve on a day to day basis. Following from this, my reading extended to incorporate studies into role models and social learning theory.

The significance of role models was investigated by Albert Bandura (1961) with the Bobo Doll experiment, which demonstrated that children learned behaviour patterns rather than genetically inheriting these factors. In the 1960s, the nature-nurture debate was a very heated contemporary issue, with social scientists investigating the extent that each of these factors contributed towards child development. There were several criticisms of this experiment, including the methodology employed. However, the conclusion that children learn by observing adult behaviour was a significant finding at the time (Shuttleworth, 2008).

Bandura’s second book *Social Learning and Personality Development* (1975), further asserted that role modelling was a very powerful influence upon children. Whereas the Bobo Doll experiment was based upon mimicry, Bandura showed that role modelling was also important for developing attitudes, competencies and creating value systems in children.

Hargreaves developed the concept of role models, outlining how a young child first acquires the beliefs and values of its parents as primary role models, followed by school where the child learns how to interact with the teacher and fellow pupils. A child learns further roles through play with other children, and through these processes, acquires the formation of identity and socialisation (Hargeaves, 1972, p.10). As the child progresses into adolescence, there are new roles to be learned through interaction with 'groups' of others. These groups can be normative or comparative, with the former being where the person wishes to adopt the values and conform to the group, the latter where the person compares themselves but may not wish to become a member of that group (Hargreaves, 1972, p.13).

A study into the importance of role models within the medical profession was conducted by Althouse et al. (1999). This research extended previous studies to consider professional role models, finding that: 'modelling is one of the most powerful means of transmitting values, attitudes and patterns of thought and behaviour to students' (Althouse, Stritter and Steiner, 1999, p.111). The qualities of the role models who were identified in the research demonstrated certain styles of teaching that can also be applied to science teaching within a school or college. For example, teaching students by direct questioning and the use of Socratic dialogue emerged as a popular method of teaching with the students. Some of the personal qualities that the role models exhibited were enthusiasm for teaching and showing students that they enjoyed their work (Althouse, Stritter and Steiner, 1999, p.116). From the research, it also appears that role models who are patient and allow students to learn from their mistakes, as well as those who encourage the students to strive for high standards are also appreciated by students.

The importance of role models for career development has been discussed in the British Medical Journal. The article 'Role modelling – making the most of a powerful teaching strategy' states that role models are: 'individuals admired for their ways of being and acting as professionals'. The report claims that apart from a formal curriculum, there is also an informal curriculum, where one learns through ‘unscripted, unplanned and highly inter-personal forms of teaching and learning’ (Cruess et al., 2008 p.719). Whilst this study was produced for the medical profession, the themes can be applied to a wider range of careers, and highlights a need for young people to meet and work with professionals from STEM subjects.

Bettinger and Long (2004) explored the impact of the gender of teachers (instructors) on female students. This study found that female instructors have a positive effect upon course selection in some disciplines, due to the fact that teachers of the same gender act as role models. The results were particularly strong for mathematics and geology, however due to the small proportion of women in fields such as physics, engineering and computer science, it was difficult to determine the effects of the female instructors in these subjects. The study was later extended to consider men as role models in female-dominated disciplines, such as education. It was found that male students with male ‘professors’ were more likely to select that particular subject.

Within the Netherlands, it has been found that female role models can have a significant influence upon attracting girls towards science. A project that allowed girls to meet female scientists revealed that ‘girls have hardly any perceptions of SET jobs and careers, and if they do, their perceptions are unrealistic or outdated’ (Booy, 2009). The project included a Girls’ Day at Eindhoven University, with female students acting as guides. It was found that girls asked different questions to boys and it was clear that they required different information. Another aspect of the project involved girls meeting female professional scientists in a ‘speed-date’ format, where a group of girls talked to female scientists in order to learn about careers in science and technology.

The issue of role models is directly relevant to my study, as the vast majority of students at the FEC have no family experience of Higher Education, therefore interaction with graduates or professionals may be restricted, if at all. Even for A level students at the FEC, many have not met or interacted with people from professional backgrounds. Through my experience as a teacher, I have found that whenever I invite a guest speaker into college, when it is time for questions, students will often ask personal questions (What A levels did you study? What music do you like?). At first, I found this rather strange but realised that they were making connections and learning about the person behind the role.

The theory behind role models can also be applied to the teaching profession, as a teacher's enthusiasm, encouragement and belief in young people can have a profound impact upon their lives. As Geoff Petty states: 'What we as teachers do is overwhelmingly more influential than what we say.' (Petty, 2009, p.21)

3.4 Wider Pedagogical Influences upon this study

Whilst the earlier sections of this chapter focus upon the literature relating to physics education, it is important to discuss the more generic issues of educational theory and practice that are inherent to my professional practice. This section will discuss some of the wider educational theories and literature that have influenced and shaped this study.

3.4.1 Vygotsky and scaffolding

Drawing together each of the studies contained within the portfolio to present this over-arching report, it is clear that a considerable aspect of my teaching practice is based upon the principles outlined by Vygotsky. He defined the Zone of Proximal Development (ZPD) as the distance between the actual level of the learner (what they can do now) to the level of potential development that they can achieve with guidance of an adult or other capable peers.

According to Mortimore: 'The aims of teaching, from this perspective, are to assist children within this zone, and to provide support and encouragement to perform successfully in areas that would otherwise be beyond them' (Mortimore, 1999, p.30). The concept of 'scaffolding' is introduced, as the help given to learners to help them reach a point which is just beyond their current capability. Any assistance given to learners which is within the learner's current capabilities or beyond the ZPD is meaningless. For the teacher, this means the continuous challenge of preparing tasks of increasing complexity in order to enable the learners to develop.

Vygotsky appreciated that when children play, they are learning about the world, particularly through the use of language. Vygotsky viewed language as 'the most important semiotic system in human activity' (Dimitriadis and Kamberelis, 2006. P.194). He believed that teachers should encourage discussion rather than simply make presentations to a class: 'Vygotsky has helped teachers to see that children learn not only by doing but also by talking, working with friends and persisting at a task until they 'get it' (Mooney, 2000, p.91). Vygotsky was aware of the differences in the meanings of words within science and mathematics compared with their meanings in everyday speech, with the scientific meanings not used not for communication but for stored knowledge (Daniels, 2001, p.155).

According to Vygotsky, when a more able child helps another child who does not quite understand, both benefit from the experience, as the process of explaining ideas enables the brighter child to consolidate understanding. Whilst this is generally regarded as good classroom practice, Daniels draws upon previous research by Tudge (1992) to suggest that benefits of collaboration may be over-emphasised by ‘confounding confidence with competence’ and that in some circumstances, may have a negative effect upon learning (Daniels, 2001, p.115).

Daniels relates social learning to gender differences by suggesting that females are more likely to engage in social learning, whereas male students may prefer to work alone. Whilst these are clearly generalisations, he suggests that girls are more likely to seek appropriate ‘scaffolds’ within the classroom, particularly from other learners. Boys, being more competitive learners, see the only legitimate scaffold as the teacher (Daniels, 2001, p.151).

3.4.2 Bernstein and language

Bernstein, in *Class, Codes and Control* suggested that both verbal and written communication of children was strongly linked with social class. He claimed that working class children used a ‘restricted code’ of speech and middle class children used a more ‘elaborate code’. The term ‘restricted’ is used to refer to words and phrases that have meanings for family or friendship groups, an informal code of speech, whereas ‘elaborate’ refers to more formal structure which is grammatically correct. Bernstein claimed that the educational progress of children was strongly linked with communication codes and that working class children were hindered: ‘not so much in the genetic code but in the culturally determined communication code’ (Bernstein, 1971, p.151). Bernstein, although heavily criticised for some of his ideas about language, looked for ways ‘to prevent the wastage of working class educational potential’ (Dimitriadis and Kamberelis, 2006, p.2).

These ideas are developed further in Bernstein’s later book *Pedagogy, Symbolic Control and Identity* where he suggests that power and control within societies lie in the principles of communication. He claims that power relations create, legitimise and reproduce boundaries, whereas control establishes legitimate forms of communication between different categories (Bernstein, 2000, p.5). Whilst he discusses ‘categories’ in a general sense, this can be applied to particular situations such as social class.

Bernstein cites a particular experiment by Holland (1981) which shows that children have different abilities according to social class. In this investigation, children were given pictures of different types of food and asked to classify the pictures into groups. Working class children based their classifications upon direct (local) contexts such as types of food which they ate, whereas the middle class children used more indirect groupings such as the origins of the food: ‘Middle class children were much more likely to offer reasons which had an indirect relation to a specific material base and the working class children were much more likely to offer reasons which had a direct relation to a specific material base’ (Bernstein, 2000, p.19). Whilst this experiment was conducted with children, it illustrates the point that the differences in learning between social classes is shaped at an early age, not only with differences in vocabulary but in perceptions of the world.

Bernstein suggests that pedagogical studies focus upon ‘what’ knowledge is being ‘relayed’ rather than how the knowledge is relayed (Bernstein, 2000, p.25). He suggests that the carrier of the communication is regulating what is being carried. Threaded throughout my study are references to the problems my students have faced with communication, whether written or verbal. Whilst I used to believe that this dilemma was caused by the nature of the subject content, I can now appreciate that students’ problems with communication can be strongly linked with social class.

Bernstein develops the concept of regulative discourse, using the specific example of authors of physics text books. He claims that writers of physics text books are rarely practicing physicists, so the subject is being ‘recontextualised’ in order to be transmitted to students. The order in which physics is taught in schools is ‘regulated’, for example, the selection and sequence of what is taught, as well as the pace of learning (Bernstein, 2000, p.34). According to Dimitriadis and Kamberelis, there is an important overlap between the works of Bernstein and Vygotsky, particularly with cognitive socialisation and educational attainment (Dimitriadis and Kamberelis, 2006, p.63).

Mercer (2003) claimed that children learn science through a discursive process and suggested that language should be used to ‘enable students to become fluent speakers of science’. He found that discussion between students developed a greater conceptual understanding of the topics, helping them to make meaning out of some of the more abstract topics (Mercer, 2003, p.359). Mercer's research was conducted within a primary school, rather than secondary or post-compulsory education. From my observations of lessons in secondary schools, it did not appear that language was significant in the learning of scientific concepts. Students were given worksheets which only required words or phrases, with no opportunity for developing their powers of expression, either verbally or in writing.

The current physics GCSE examination papers have a large proportion of multiple choice questions with minimal opportunities for extended writing. As schools are under pressure to achieve targets, it is understandable that teachers focus upon the skills necessary for examination success. Consequently, the lack of strong written communication skills evident in many of the students at the FEC may be a direct consequence of the fact that these skills are not necessary for success at GCSE.

3.4.3 The emotion of teaching

In 'Thinking about Feeling: The Emotions in Teaching' (1996) Nias claims: 'As an occupation, teaching is highly charged with feeling, around, by and directed towards not just people but also values and ideals' (Nias, 1996, p.293). She believes that the feelings and emotions of teachers have been neglected since the 1960s and largely dismissed by both academic and professional research. Nias explains that teaching involves 'intense personal interactions' with large numbers of pupils who can be energetic, spontaneous and immature, having to manage and direct the students into ‘culturally approved channels’ (Nias, 1996, p.295).

Nias explains that teachers invest their ‘selves’ in their work, often to the point of merging their personal and professional identities. She suggests, along with Noddings, that teacher’s ‘stories’ or autobiographical accounts can lead to greater cognitive insight and discussions about teaching: ‘Teachers can grow personally and develop professionally through making a narrative of their whole lives’ (Nias, 1996, p.302). Within chapter two of this report, I have produced my own such ‘story’ and fully agree that writing this chapter forced a deep reflection of my career. Throughout the entire chapter, my professional and personal identities are intertwined, with my feelings, emotions and beliefs shaping my identity as a teacher.

Hargreaves (1997) discussed the vital role that emotion plays in teaching and suggests that efforts to improve teaching have focused upon skills and standards, rather than reaching the heart of ‘what a great deal of teaching is about: establishing bonds and forming relationships with students, making classrooms into places of excitement and wonder, ensuring that all students are included and no one feels outcast’ (Hargreaves, 1997, p.ix).

Hargreaves argues that if educational change is to be productive, it must examine the moral and emotional texture of practice, probe into the heart of what good teaching is, and what motivates a teacher to do their work well. He believes that good teaching is more than being efficient, possessing knowledge and developing competencies, it is ‘infused with pleasure, passion, creativity, challenge and joy’ (Hargreaves, 1997, p.12). Hargreaves agrees with Noddings (1992) in that educational change often overlooks the value of care, whilst the focus is upon strategic planning, leadership and management (Hargreaves, 1997, p.13).

From a different perspective, Damasio conducted a neurological study and claimed that emotions are integral to rational decision making. As mentioned in Chapter 2 of this report, Damasio studied the neurological reactions within the brain which controls emotions and feelings, finding that emotions were far more integral to reasoning and decision making than previously thought (Damasio, 1999).

In a later study ('Emotional Geographies of Teaching', 2001) Hargreaves explored how teachers' emotions are embedded in the conditions and interactions of their work. He suggests that teachers draw upon their own emotional understandings to interpret, unravel and respond to the emotional experiences of others. He claimed that different occupations have different emotional experiences and expectations, which can then affect the identities of people within different professions. He claims:

> 'As an emotional practice, teaching activates, colours, and expresses the emotions of teachers and those they influence. Teachers can enthuse their students or bore them, be approachable or stand-offish with parents, trust their colleagues or be suspicious of them. All teaching is therefore inextricably emotional, by design or default.'
>
> (Hargreaves, 2001, p. 1057)

Hargreaves discusses the fact that teachers today often find they are teaching children from different social or cultural backgrounds to themselves, and that this may present problems with teachers making assumptions about the parents or backgrounds of the children (Hargreaves, 2001, p.1066). He found that when teachers were praised or appreciated by parents, this resulted in very positive emotions and teachers greatly welcomed this feedback. Criticism from parents proved to be one of the strongest sources of negative emotion for the teachers in the study (Hargreaves, 2001, p.1068).

It is interesting to note that Hargreaves suggests teaching has a feminine caring ethic, which is trapped inside a bureaucratised structure. He contrasts this with the idea that professionalism requires emotional detachment, and that male-dominated professions avoid ‘emotional entanglements’ (Hargreaves, 2001, p.1069). Hargreaves suggests in his conclusion that teaching, as a profession, should require less ‘overload of policies and curriculum’ but allow for more opportunities to develop emotional understanding of the children we teach (Hargreaves, 2001, p.1077).

Cooper (2004) discusses empathy in education and outlines the need to create the right climate for young people to learn. In section 3.4.1, I have discussed how Cooper has drawn upon Vygotsky to suggest that the scaffolding required to help young people can be emotional as well as cognitive. Cooper suggests that empathetic tutors build a student’s self-esteem and self-worth, build trust and security, which then leads to positive ambience (Cooper, 2004, p.20). She also points out that the current climate of education over-emphasises the importance of standards and assessments, and that along with large classes and competitive atmospheres, reduces the importance that should be placed upon caring within the teaching profession (Cooper, 2004, p.20).

As mentioned in section 3.4.1, the work of Vygotsky led to the recognition of the importance of language in learning, which was discussed in section 3.4.2 and the affective aspect of learning which is discussed within section 3.4.3, which both underpin the studies contained within the portfolio.

3.5 Summary

From this literature review, it is clear that considerable research has already been conducted into physics education, both for issues pertaining to the teaching and learning taking place within the classroom, as well as the factors outside of the classroom. The literature includes work that is qualitative such as that of Stewart (1998) and Osborne and Collins (2001), as well as quantitative studies (McClune, 2001). Most of the research, however, has been based upon pupils in secondary schools, rather than post-compulsory education.

Sections 1 and 2 of the portfolio show that over the past ten years, the numbers of pupils who are studying GCSE physics has increased, as well as the proportion of girls who study this subject (JCQ, 2011). It could be inferred that the increase in participation at GCSE may be a result of the initiatives and interventions aimed at this particular age range.

Current research into physics in post-compulsory education is far more limited, yet this is where some of the real problems emerge, particularly with the under-representation of girls. Exploring the factors which influence subject choice, and methods of engaging young people with the subject, will lead to a greater understanding of the issues and this will hopefully increase the numbers of physics students at the FEC and then at university.

The research contained within this chapter provides a framework for my own subsequent investigations. The first section of this chapter outlines the need to increase the number of young people who study STEM subjects, at every level of the education ladder. This underpins all of the sections contained within the portfolio. Section 3.2 of this chapter relates to the factors within a classroom where the teacher can make a difference. This contributes towards sections 3, 4, 5, and 6 of the portfolio. Section 3.3 of this chapter discusses some of the wider issues, some of which may be outside of the control of the individual teacher, but we can improve the situation with a greater awareness and understanding of these issues. Section 3.4 of this chapter presents the wider, more generic themes which underpin this study.

The section within this chapter on methods of assessment (3.2.4) formed the basis for Section 4 in the portfolio, as it was clear that the research conducted by McClune (2001) was ‘small-scale’. Having access to a larger sample of data over a longer time period provided more information to evaluate than the original study.

Each of the investigations discussed in the literature review has been conducted with widely differing cohorts of students, from all over the United Kingdom, and in some cases, from other countries. For my portfolio, I have focussed upon a specific group of students, those who attend a particular FEC in the north east of England. As the main provider of post-compulsory education in the city, and one of the largest FECs in the county, it has a greater number of students than any other educational establishment in the area. This provides a strong starting point for academic research as the number of students presents greater opportunities for analysis of data.

Using a mixed methods approach, combining quantitative and qualitative data, ten sections have been produced which examine the key research questions from different perspectives. Whilst my investigations extend the previous research, the primary motivation for conducting this research has been to determine the important factors that influence young people within this area, who are primarily working class students in a city facing the effects of economic recession.

Chapter 4 Research Design and Methodology

This chapter will consider the research design and methodology that have been used to produce each of the sections contained within the portfolio. A good starting point for designing the methodology was the text *Research and the Teacher,* which stated: ‘Whilst not underestimating the difficulties involved in teachers undertaking research, we emphasize the importance, positive value and excitement of teacher-based research’ (Hitchcock and Hughes, 1995, p.7). They explain that educational research is similar to that of social science, with a need to understand the tools and techniques of this latter discipline (Hitchcock and Hughes, 1995, p.11). They claim that it can be more difficult for classroom teachers to conduct research, compared to that of an outsider, as ‘one is part of the situation one is investigating’. An independent researcher can maintain greater distance from the investigation, and at the end of the investigation, may have no further contact (Hitchcock and Hughes, 1995, p.45).

This latter point pervaded the entire course of this study. As a practising teacher, I was immersed in the education of my students and it is difficult to assess whether one particular strand of my investigations could be evaluated in isolation. Unlike research into physical phenomena, where all of the relevant variables can be controlled, educational research is less structured. The students liked the fact that I was conducting educational research, and on the whole, were fully supportive and appreciative that my efforts to be a better teacher would help them to achieve good results. Conducting research as a practising teacher has advantages in that it is helpful for both the teacher and the students, yet it has disadvantages in that it can be difficult to maintain an objective and critical stance towards the situation.

The complete study is of a mixed-method design, containing quantitative evaluations as well as qualitative studies. Creswell and Plano Clark have produced a useful text on mixed-methodology, outlining that: ‘Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone’ (Creswell and Plano Clark, 207, p.5). They perceive quantitative methodology as closed-ended information, with a weakness in that it does not provide the researcher with the context of the situation. Qualitative methodology provides more open-ended information, but is subject to the personal interpretation of the investigator. They suggest that the mixing of methods leads to a stronger study than either quantitative or qualitative used alone (Creswell and Plano Clark, 207, p.6). By using a range of methods, this produces a triangulation of data, continually evaluating the reliability of the methods employed.

Hitchcock and Hughes propose that when conducting educational research, the key research questions should be formulated first, which then lead to devising the methodology which is most appropriate to answer the questions. They suggest that the researcher develops an ongoing internal dialogue of continually reflecting and refining, combined with external dialogues with peers and supervisors (Hitchcock and Hughes, 1995, p.81). Once the research questions have been devised, this would be followed by the literature review and consideration of the ethics, which would then further refine the methodology. When this has been established, one can proceed with the gathering of data, analysing this information, then evaluating and reflecting upon the significance.

As each stage of the portfolio progressed, I actively sought feedback and constructive criticism from professionals both inside and outside of the college, in order to conduct the dialogues suggested above. At first, I was rather apprehensive about showing other professionals my work, however, the people who were most (constructively) critical were the people who helped me the most in my personal learning journey.

The process of actively seeking evaluations for each of the ten main sections of the portfolio enabled me to refine my methods in accordance with the suggestions for improvements. This is, perhaps, the main factor which distinguishes a Professional Doctorate from a PhD thesis, in that the former is conducted within the strong foundation of professional practice, with a purpose to improve that practice, which is not confined to the researcher but contributes to the wider profession. The next sections of this chapter discuss the methodologies employed in the study. For greater clarification, I have provided a chart to show how each of the sections contained within the portfolio used different methodologies (Chart 4.1).

It is interesting to note that school improvement tends to make use of qualitative research, whereas school effectiveness research focuses on quantitative methods (Middlewood, Coleman and Lumby, 1999, p.3).

Chart 4.1

Methodologies used within this Study

SECTION	Quantitative	Qualitative	Action Research
1	Analysis of JCQ and LA data Analysis of FEC data (AS and A level enrolments)	Focus Group with students Interviewed Head of Science	
2	Analysis of UCAS and UKRC data Analysis of FEC data (university progression)	Interviewed contacts from local universities	
3		Survey of students preferred learning styles	Project Think!
4	Analysis of Examination Results Content Analysis	Study of students' original scripts	
5	Analysis of exam results, progression to A2 and selecting physics related university courses	Survey of students who participated in the project Compared samples of work before and after the project	Project with the Science Learning Centre
6	JCQ Data	Investigated the range of science support agencies that can help students and teachers	
7	Analysis of JCQ and FEC data	Interviewed students about parental involvement.	
8	Analysed UCAS data for the FEC		
9	Analysed data from PROSPECTS and UNISTATS	Investigated careers within the county	
10		Case Studies	
11		Feedback from former students	

4.1 Quantitative methods

From a scientific background, I am perhaps most experienced with collecting, interpreting and evaluating numerical data. Borg and Gall, in *Educational Research* state: 'Quantitative researchers attempt to be objective, meaning that they wish to develop a view of the world as it is 'out there', independent of their own personal biases, values and idiosyncratic notions' (Borg and Gall, 1989, p.23).

Within Section 1 of the portfolio, national statistics provided by the Joint Council for Qualifications (JCQ) website were used to provide data for the number of candidates who studied GCSE qualifications in recent years. This information was used to produce the table showing the number of GCSE candidates for science and mathematics in 2000, 2009 and 2010. It can be seen from this data that the proportion of candidates for the separate sciences has increased, with the number of candidates for the double award science (integrated science courses) decreasing.

In order to assess whether the national trend applies to this particular city, I obtained information from the Local Authority regarding the number of candidates for GCSE courses in 2009 and 2010, as well as the number of students who studied A level physics examinations in the Roman Catholic Sixth Forms within the city. According to the Freedom of Information Act, numerical data are made available upon request although the data was limited to the state providers of education within the city, with no information regarding the private sector.

For data relating to the number of A level students at the college, I contacted the department within the college that contains all of the records and information about students – MIS (Management Information Systems). I was told that all records before 2001 had been destroyed due to Data Protection Regulations. This seemed to be very strange, for while I could understand the need to destroy confidential records, eradicating all records of the past would prevent any longitudinal research from ever being conducted in the future.

Within Section 2 of the portfolio, I analysed information provided by the UCAS statistical services website. UCAS holds quantitative information on the number of applicants from 1996, offering a statistical search based upon factors such as ethnicity, gender, age, domicile, and subject choice. I contacted UCAS to ask for information relating to the proportion of applicants for physics degrees that came from the independent sector, as well as the proportion of students at the nearest selective university (1994 Group) who came from independent schools. I was told that if I required this information, it would cost a minimum of £200 to answer each query. I also contacted HESA in order to determine information regarding social class and subject choice, which also required a fee to answer questions relating to social class. I later found information through the Institute of Physics.

Within this section, I also analysed primary source data, obtained from the FEC, on the students who had progressed to university to study for science related degree courses. Each year, UCAS provides the college with a list of all students who have been placed into Higher Education degree programmes. The FEC provided me with spreadsheets of empirical data, taking care that personal information such as names and addresses were removed. Apparently I am the only member of staff who has ever asked to analyse this information.

Section 4 of the portfolio was based upon the evaluation of primary data, analysing and evaluating the raw examination results over an extended period. The research by McClune suggested that the modular structure of A levels was more favourable for boys than girls: ‘There is some evidence to suggest that boys are more likely than girls to take advantage of some of the features of modular examinations’ (McClune, 2001, p.79). I was particularly interested in this statement and wanted to determine the extent that this was true for our students at the FEC. I was also keen to determine whether any significant differences emerged between the performance of girls and boys in the different modular examinations, and whether this would reveal any differences between girls’ and boys’ conceptual understanding of the subject.

In order to extend McClune’s study, I analysed the primary source data of the A level physics modular examinations from 2004 to 2010. The first analysis was conducted in 2008, which showed that there was particular under-achievement in the health physics module. One may think that this would be strikingly obvious from the examination results, however it was masked by the fact that the modules were assigned different weightings, and the optional module contained additional synoptic questions. After working out the marks for each component separately, this revealed that the Health Physics module was, in general, the one in which students achieved the lowest mark.

After recalling a selection of original scripts, I found that the students were particularly weak at the questions which required written communication and the ability to recall extended factual information. A content analysis was then conducted which showed that the Health Physics module had a greater proportion of discursive style questions than other papers. The Examiner’s Report was referred to, which showed that the problem with written communication was not confined to students from our college, but was in fact a national problem (OCR Examiners Report, 2008, p.21).

Within Section 8 of the portfolio, I conducted another analysis of primary data using UCAS information provided by the FEC. The raw data was used to determine the progression trends for students from a large college of further education. The analysis showed that choice of university degree was not necessarily linked to future employment, which was particularly surprising as one may have expected a college with predominantly working class students to have a greater proportion of students selecting degree courses that would be connected with future employment possibilities. Upon my quest for information, I was told that statistics are presented to the governors in the form of a short report, but my request for a copy of this report was refused (with no reason provided).

Section 9 of the portfolio uses data from both the Prospects website and hand book in order to provide an analysis of the employment of graduates. Unistats is another useful website that provides statistical information on graduate employment (UNISTATS, 2011).

4.2 Qualitative methods

Whilst the quantitative methods involved the analysis of numerical data, this section will explore the range of qualitative methods that were used throughout the portfolio, including case studies, interviews, focus groups and surveys. Hitchcock and Hughes suggest that qualitative methodologies are more appropriate for educational research, as they lead to a greater understanding of the situation:

> ‘Research does not take place in a vacuum, it always has a context. Social and educational research is conducted by thinking, feeling human beings and in qualitative approaches, the researcher takes on a highly interactive profile.’
>
> (Hitchcock and Hughes, 1995, p.39)

The qualitative methods were used as means of finding out the reasons that supported and underpinned the quantitative data. Within Section 1 of the portfolio, after evaluating the numbers of young people who study physics at GCSE and A level, I wanted to determine the reasons why students chose not to study physics at A level, so I contacted some of the Heads of Science from our partner schools. They provided first hand information upon their perception of the problem, specifically the shortage of specialist physics teachers and a surplus of biology teachers, who were often coerced into teaching physics within our partner schools.

Within this section, I held a focus group with a small number of A level students who had chosen to study science A levels at the college, but not chosen to study A level physics. In *Research and the Teacher*, it is emphasised that for group interviews, small groupings of six students would be the most productive (Hitchcock and Hughes, 1995, p.161). Focus groups are a particular type of group interview where the participants are selected to discuss a particular topic or theme. According to Cohen: ‘Their contrived nature is both their strength and their weakness’ (Cohen, 2007, P.376).

There were several options that I considered before holding this focus group, however I decided to focus upon the reasons why young people were not choosing to study physics A level. I invited the students who were studying biology and chemistry A level but not physics, and all five students agreed to participate in the focus group.

Hitchcock and Hughes (1995) outline the advantages of recording interviews by tape or video. The students in the focus group were not keen on either, so I made notes during the group interview. During the interview, there were various questions to obtain factual information, such as current A level subjects, choice of degree course and factors relating to previous schooling. There were more open-ended questions about the factors that influenced their decisions. The students raised issues such as course content, the teachers and relevance for a future career.

Cohen (2007) and Hitchcock and Hughes (1995) discuss potential problems with this type of study in that the investigator may need to prevent some of the participants from dominating the conversation, avoid situations were some of the participants feel exposed or uncomfortable in front of peers, and ensure that the participants do not become distracted or veer from the topic. Due to the composition of this group, none of these factors were a problem.

Individual interviews may have produced more formal responses, but the focus group presented the opportunity of observing how this small group of students interact with each other and how they discussed and agreed on common themes which were important to them. The answers that these five students provided are therefore not representative of the whole cohort of students within the college, but provide a valuable insight into why students were not choosing to study physics A level (when they had strong GCSE results and could have progressed to study this subject).

Within Section 2 of the portfolio, I took the opportunity of contacting the four geographically nearest universities to ask about physics degree courses. I received a very detailed reply (by email) from the one university that offers physics degrees in the region, explaining that the success of their department was partially due to the international research, and therefore the funding, that the department received. The other three universities in the area do not offer physics degrees, but a representative from each of these universities replied to my questions.

Within Section 3 of the portfolio, I conducted a survey of my students, which was based upon recommendations suggested by the Institute of Physics report ‘Girls in the Physics Classroom: a Teacher’s Guide for Action’ (Hollins, 2006). The report provides practical advice for physics teachers, irrespective of gender, and encourages the use of surveys as a means of promoting dialogue between teachers and students on issues relating to teaching and learning.

The survey that I conducted was a paper-based questionnaire that I gave to 30 AS and 10 A2 students during 2009. Due to the relatively small number of students, I could then use this as a framework for subsequent discussion and small individual interviews. When conducting surveys, one of the considerations is the nature of the group itself and the limitations presented by the students who are participating in the survey. As all of the students in this survey studied A level physics, whether first or second years, they were a self-selecting group who all brought different experiences to the classroom but were all bound by their own choice to study A level physics.

I explained to my students that finding out about how they learn was not with the intention of adapting teaching methods to suit the students preferred learning styles, as the educational journey could not be achieved without developing skills that were outside of students' preferred 'comfort zones'. Whilst I avoided too much educational pedagogy when discussing this with students, I found that I needed to explain the difference between 'needs' and 'wants' very carefully. As mentioned in Chapter 2 (2.4), Brookfield found that students could often confuse their needs with their personal preferences, and that students were not always in the best position to decide what was in their best interests (Brookfield, 1995, p.20).

Cohen discusses the importance of vocabulary in surveys and how words have different shades of meaning for each of us (Cohen, 2007, p.322). Therefore, I assigned words that were generally used by students, rather than words outside of their everyday vocabulary. Although this survey was part of a qualitative investigation, it employed a small-scale quantitative analysis of the responses. In order to convert the responses to more quantitative data, I assigned a rating scale for each response, then calculated the average point scores for each activity and ranked them in order. According to Cohen, rating scales are widely used in research as they present an opportunity to 'fuse measurement with opinion, quantity and quality' (Cohen, 2007, p.327).

Cohen outlines some of the advantages of rank ordering, but suggests that there should be a maximum of five choices so that the task for the respondent is not too over-whelming. Some 'cautionary factors' are pointed out, such as the fact that there is no way of knowing if the respondent is telling the truth. Some respondents deliberately avoid the extreme ends of the scales and opt for midpoints. (Cohen, 2007, p.325)

Section 7 of the portfolio includes a study into home background as an important influence upon the learning process and future decisions made by young people. The findings from a survey conducted with my second year A level students were presented. For this survey, care needed to be taken as it involved some questions that involved the students' families. All students were informed before the survey (and all interviews) that they must not respond to any question that they do not feel comfortable with.

Due to the small group, with only two girls in that particular A level physics class, the responses cannot be generalised to represent all of girls who study physics A level. This was simply a 'snapshot' picture of the students in my A level physics class. If the same survey was conducted in a later academic year, the responses may have been different. It did, however, illuminate some of the issues which are relevant to this study.

Within Section 9 of the portfolio, I explored the range of scientific careers within this area. I began this study by contacting the Head of the local Connexions Service, who recommended one of his senior advisers to act as a point of contact with whom I could discuss issues relating to science careers within this area. Working with this Adviser, I learned more about the function of the Connexions Service and how they catered for the needs of learners up to the age of nineteen. I was very surprised to learn that each university operates its own specific Careers Service, which operate completely independently, and are not connected to either other universities or the Connexion Service. In order to pursue this line of research, I made personal contact with two local university career teams.

Within Section 10 of the portfolio, I have presented a case study of one of our former students from the FEC who progressed to study astrophysics at university. Hitchcock and Hughes discuss the purpose of case studies as: ‘an in depth study of a single event’ where the researcher investigates social behaviour in a particular setting and the factors influencing the situation (Hitchcock and Hughes, 1995, p.317). They explain that case studies focus on people, so it is their perception of the situation which is of importance.

Yin (2012) suggests that the advantages of case study research is that it reveals how case study participants ‘construct reality and think about situations, not just to provide answers to a researcher’s specific questions’ (Yin, 2012, p.12). He also outlines some of the problems when conducting case studies, for example, a lack of rigour, little basis for generalisation and the fact that they can take too long to complete. Yin further explains that case studies can form an important part of a mixed-method study.

Yin defines the ‘unit of analysis’ within a case study as the case itself. Applied to Section 10 of the portfolio, the initial case was the female student from the FEC who had pursued astrophysics at university. This was originally intended to be a single-case study, however, after developing links with Durham University, there was an opportunity to discuss the same questions with three female physics research students, making this section into a multiple case study.

Yin classifies case studies into three categories: Exploratory (initial pilot studies which generate further research), Descriptive (which provide a narrative account) and Explanatory (which generate new theory or test existing ones). If using this classification, then the case studies in this study would be descriptive. The objective of these case studies was to explore the reasons why some women are attracted towards physics, which is a sub-unit of the whole study of physics in post-compulsory education. Therefore they are embedded rather than holistic case studies (Yin, 2009, p.53).

In preparation for a case study, it was necessary to gain consent from the participants, as well as assuring them of privacy and confidentiality. Yin states that when case studies take the form of interviews, the interviewees' responses are subject to bias, poor recall and poor or inaccurate articulation (Yin, 2009, p.109), therefore I took care to make sure that each person could give due consideration and reflection to their responses.

For the first study, I interviewed the young woman then refined this by writing out some specific questions and she produced written responses for me to use in the study. This ensured that she was comfortable with the information, although this was primarily a concern on my part rather than that of the interviewee. Similarly, with the three women who were currently conducting PhD level research in astrophysics, I used the method of interviewing first in person, then clarifying particular responses with written questions and answers.

Within Case Study Theory, there are a range of methods that can be applied towards analysing data and as Yin states: ‘there is no automated algorithm when analysing narrative data’ (Yin, 2012, p.15). As the purpose of these studies was to gain an insight into what attracted them towards the study of astrophysics, pattern matching was the most appropriate method for evaluating the responses. It was clear that the wonder of space held fascination for all four women, each of whom held a genuine passion for the subject (interest). Each of the women articulated that they found the subject difficult at times, but believed that it was worth pursuing to achieve a sound understanding (they enjoyed the subject because it was difficult). The third point that I found most interesting was that each of the four women came from middle-class well-educated backgrounds where university education was expected of them.

The most surprising feature of the case studies with the three research students was that each of them separately expressed concern about their future employment, believing that it would be difficult to forge a career in astrophysics.

Yin (2009) provides advice on presenting case study reports according to target audience. The case study of the former student from the FEC was written up in one particular manner which was appropriate for current students at the FEC and uploaded onto the physics VLE site. I made another abridged version with a photograph of this young woman to be pinned onto the careers section of the laboratory. Then the overall findings from the four separate case studies were presented in Section 10 of the portfolio.

As mentioned, Yin outlines that one of the main problems with case studies is the difficulty in making generalisations. As there were only four women who participated in this aspect of the study, then it must be stressed that any findings do not represent the views of all women who pursue careers in physics. The views expressed within the case studies simply illuminate the situation and produced some interesting themes.

Flyvbjerg (2006) discusses some of the problems with case studies in his paper ‘Five Misunderstandings about Case Study Research’ and refutes the criticism of the difficulties in generalising from specific case studies. He argues that generalisations are ‘over-rated’ and that the ‘force of example’ from a single case is underestimated (Flyvbjerg, 2006, p.228). He claims that case studies may not always be easy to summarise or present according to neat formulae, as ‘good narratives typically approach the complexities and contradictions of real life’ (Flyvbjerg, 2006, p.237).

Within Section 11 of the portfolio, I have included feedback from former physics students from the FEC. It must be stressed that this is not a random selection, as they are from students who have remained in contact with me and keep me informed of their progress. A more random selection of former students may reveal quite different comments, however, these students clearly had a positive experience of A level physics and appreciated my support during their time at the college and wanted to be involved in my journey towards a professional doctorate.

4.3 Action research

Within the portfolio are two studies which are essentially Action Research Projects. When preparing for these projects, I read several texts in conjunction with the training that I was receiving with the Science Learning Centre at Durham. The concept of 'action research' was developed by Lawrence Stenhouse in the 1970s, who was keen to move educational research out of universities and into classrooms, in order to focus upon the practices of teachers (Ruddick and Hopkins, 1985, p.15). Some of the texts on action research methodology adopt a theoretical approach, such as that of McIntosh, which considers the philosophical concepts behind action research. His definition was that:

> 'Action research is grounded in an eclectic mixture of philosophical thinking around transcendence, of ethical thinking and values, and of recognition that it operates in a domain of uncertainty as to how it apprehends the nature of the action.'
>
> (McIntosh 2010, p. 37)

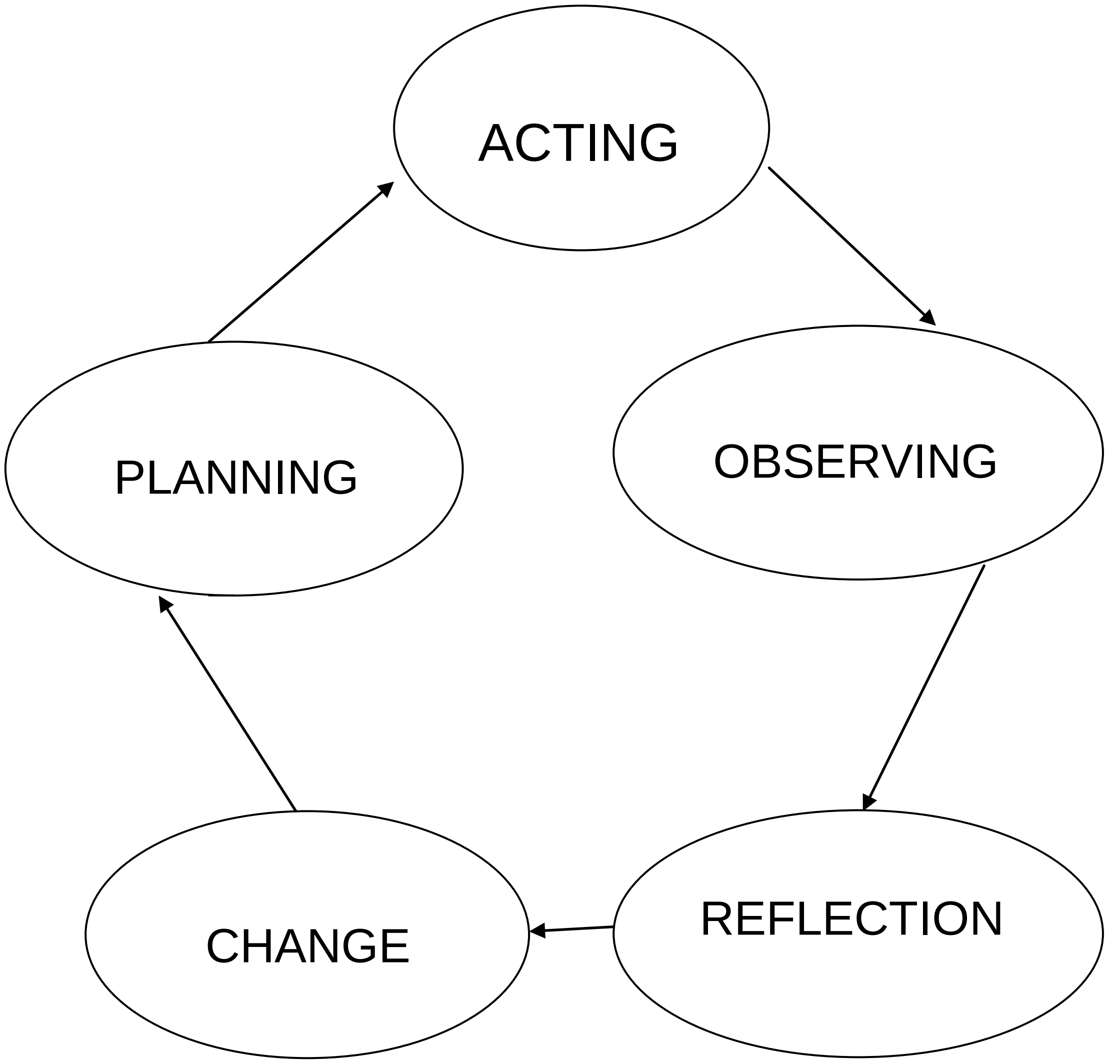
Whilst it is outside the scope of this study, his chapter on the neuroscience behind the process of conscious and unconscious thought was intriguing, questioning how the grey matter in our brains can lead to the processing of information, knowledge and understanding of the world.

Elliott has also written useful texts on action research and claims that: 'The fundamental aim of action research is to improve practice rather than to produce knowledge' (Elliott, 1991, p.49). Elliott suggests the action research integrates teaching, professional development, curriculum development, research and philosophical reflection into a 'unified conception of reflective educational practice' (Elliott, 1991, p.54). His section on 'Techniques and methods for data gathering' provided a valuable guide for planning the methods used to analyse the impact of the project. He discusses the need to triangulate data with a range of sources, which led to my evaluations of using both quantitative data (pass and progression rates) as well as qualitative methods (comparison of samples of students' work) to evaluate the impact of the project in Section 5 of the portfolio.

Hitchcock and Hughes explain that action research is increasing its importance within the fields of educational research, and claim that it is characterised by the term 'action', with the aim to improve and reflect upon practice (Hitchcock and Hughes, 1995, p.27). They also suggest that action research is cyclical, as represented in Chart 4.3 overleaf, with continuous reflection and cyclical processes. They also discuss the need for collaboration, both inside and outside of the organisation. Some of the criticisms of action research, however, include the nature of the reflection undertaken, the rigour of the process and the overall value of the contribution to research (Hitchcock and Hughes, 1995, p.30).

CHART 4.2

The Cyclical Approach of Action Research



(Hitchcock and Hughes, 1995, p.29)

A strong advocate of action research is Jean McNiff, who is currently one of the leading experts on teacher-based action research. She explains that whilst traditional research may have been conducted by academics, who then pass on their findings to classroom teachers, this may not be as effective as classroom-based research by teachers. According to McNiff: ‘I am advocating the establishment of a new tradition of educational enquiry that focuses on the integrity of individuals in the living reality of their own locations’ (McNiff, 1993, p.49). Her texts are written in a very open, fluid and engaging style, which are accessible to a wide range of readers. McNiff writes in a direct manner that can inspire ordinary practising teachers, unlike some of the texts on action research which are produced for academic reading. McNiff sees teachers as learners, and that good teachers are learning all of the time: ‘...who care enough first to make an unqualified commitment of self to the education of self, in the interests of the education of others’ (McNiff, 1993, p.21).

Section 3 within the portfolio contains a report conducted into a project conducted within the FEC (Project Think!), which was primarily to develop Higher Order Thinking Skills. The project was limited to a small group of teachers who wanted to develop a range of resources, test them with students, and share our findings with teachers from other disciplines. During the course of this project, I developed a range of different classroom methods and strategies that would engage students in the study of physics, with a particular interest upon how to stretch the more able students to achieve high grades. The resources that I developed over this period evolved as they were being ‘tested’ by my students.

Often ideas that I devised were not as popular with the students as I had anticipated, then other ideas for which I may have held reservations were more popular than expected. It was not an exact science, but a working project that had a direct impact upon my students, who were open, enthusiastic and good natured at all times. I found that students liked the fact that I wanted to be a good teacher, that I wanted them to achieve the best grades possible and above all approached all lessons with good humour. Being fortunate to have A level students who were appreciative of my efforts was very significant indeed, for they eagerly embraced new activities and were very interested in the fact that I was sharing their work with colleagues. All of the teachers who participated in the project sent samples of their resources to the Co-ordinator, although the work was not presented as a final coherent body of work.

Section 5 of the portfolio presents the Action Research Project that I conducted with the Science Learning Centre (2010). In order to prepare for conducting this project, I attended three training sessions at the Science Learning Centre in Durham. This was an excellent opportunity as it enabled me to discuss my work with physics teachers from other establishments, sharing our concerns and supporting each other fully. The facilitators were inspirational and encouraging, providing support at each stage of the research.

The project involved the development of blogs and wikis using the college's virtual learning environment, specifically to engage students with physics outside of the classroom and to encourage students to create their own pages, research topics of interest and to share their interests with other students. I also wanted to develop activities that would enable students to develop their written communication skills in a way that they enjoyed. One of these activities was to encourage students to keep learning diaries, to reflect upon what and how they had learned, and to discuss difficult topics with each other.

As McNiff states when discussing methodologies to use for action research projects: ‘The struggle is not to find the best way, the struggle *is* the best way, provided we recognise one another as part of the same struggle, similarly engaged in doing the best we can’ (McNiff and Whitehead, 2007, p.138).

Table 4.3 presents a timeline of the various stages of the Action Research Project, showing the stages of the investigation.

TABLE 4.3
Timeline of Action Research Project
(Section 5 of the Portfolio)

DATE	ACTIVITY
August 2009	Formulated proposal and applied to the Science Learning Centre to conduct an Action Research Project. Proposal refined and accepted.
October 2009	Attended first training session at the Science Learning Centre in Durham (Introduction to Action Research). Attended training sessions to develop the VLE (Blackboard). Set up physics web pages, introduced project to the students.
November 2009	Obtained samples of students' written work to use as a future comparison. Encouraged AS Students to use wiki sites. Encouraged individual students to develop blog pages. Regular meetings with the facilitator at the SLC to reflect on my study.
December 2009	Regular monitoring of sites. Encouraged students to use these sites outside of the classroom. Revisited the purpose of the project with the class and group. discussion about engagement with the project.
February 2010	Attended second training session (Collecting, evaluating and interpreting results). Encouraged by course facilitator to devise a questionnaire to explore students' interests in physics. Reflection upon course content and specific skills associated with physics.
March/April 2010	Regular monitoring of sites – Students had developed their own strands, some used the site to upload revision notes, some used it to upload wider aspects of physics and some used it is a 'learning diary'.
May 2010	Attended third training session (Writing the report). Students participating in the project completed their AS course.
June 2010	Presentation to the Science Learning Coaches. Reflection of study prior to students completing course.
August 2010	The AS results and progression from AS to A2 data available. Produced draft report.
September 2010	The students produced written exercises, similar to those conducted at the start of the study to provide a qualitative comparison. Students who participated in the project were asked for feedback on the project.
October 2010	The number of students who applied to study physics related courses at university was available. The long version of the report was produced and shared with the Director of Learning Resources and the Project Co-ordinator. A shorter version of the report was produced and uploaded onto the SLC portal.
December 2010	Article about the project featured in JISC newsletter.

4.4 Definitions of terms and delimitations of this study

At this point, it may be useful to consider what is meant by the term ‘professional practice’. At various points in this study I have referred to teaching practice, so it needs a clear definition. Schatski discusses the fact that ‘most thinkers who theorize practices conceive of them, minimally, as arrays of activity’ (Schatski, 2001, p.2). He believes that at the central core of a practice will be a set of shared understandings and skills, defining practice as ‘a set of doings and sayings organised by a pool of understandings, a set of rules and a teleo-affective structure’ (Schatski, 2001, p.53). This latter word is a combination of teleology, which is an orientation towards ends, whilst affectivity is how these things matter to a person.

Barnes discusses social practices as the ‘accomplishments of competent members of collectives’ (Barnes, 2001, p.25). Therefore in teaching, practice refers to the understandings, the rules and the values that a professional adheres to in order to provide the optimum educational opportunities for the students.

The text: *Professional Knowledge and Professional Practice* explains that responsibility towards clients is an essential component of the idea of a profession. Accountability is meeting the requirements of set procedures and standards, whereas responsibility is that ‘voluntaristic commitment to a set of principles governing good practice’ (Hoyle and John, 1995, p103). They also discuss the fact that reflection on one’s practice is a significant component of being a ‘professional’ (Hoyle and John, 1995, p.124).

Hoyle and John discuss that in Britain, the role of the teacher has been expanded far more than simply developing knowledge and skills, as it is now expected that teachers have developmental and socialising concerns. They state that there has been: ‘an explosion of expectations to the point of role overload’ including pastoral care, responsibilities to parents, personal and social education, tackling issues such as sexism and racism, as well as the professional development necessary for the teaching (Hoyle and John, 1995, p.115). They discuss the fact that this is very different to the role of a teacher in France, where teachers focus only upon academic achievement. A point that made immediate impact on a personal level was their concern that: ‘There is potentially no end to the time which teachers might spend out of school hours in preparation, marking and attending meetings’ (Hoyle and John, 1995, p.116).

Turner, in *The Theory and Practice of Education* (2007) includes a chapter on classroom management as his first consideration of educational practice, so the concept of what constitutes ‘practice’ differs from the theoretical texts to the more pragmatic and vocational application of the term. Even within educational texts, the meaning of ‘practice’ can vary.

The codes of professional practice for college lecturers, as stated by the Institute for Learning (2012) outlines the ‘behaviours’ expected of members:

- Integrity
- Respect the rights of learners and colleagues
- Care for the safety and welfare of learners
- Disclosure of a criminal offence

- Responsibility

(IfL, 2011)

Jarvis, in *The Theory and Practice of Teaching* has a more altruistic concept of teaching:

> 'Underlying the whole exercise of teaching and learning is that together, teachers and learners, who are also learners and teachers, must recognise that it is human beings (faces) who constitute the process. They are always in the process of becoming – growing and developing – and reaching beyond where they are now, and the nurturing of this process is human care and concern for the Other'.
>
> (Jarvis, 2006, p.5)

Therefore professional practice, in my use of the term, means the things that we do, as well as the way that we conduct ourselves, which often stretch beyond contractual duties to encompass responsibility, care and helping others to succeed.

Within this study, one of the main delimitations are the physics students at the FEC, who have willingly engaged in all aspects of the study, however as they have already made the decision to progress in this subject, they are not representative of all young people of this age within the city.

Despite many attempts to work with our local partner schools, co-operation from the respective science departments has not been forthcoming. One of the main reasons given by the school teachers was they are far too overloaded with their own teaching to engage in additional activities. If the work load for secondary teachers is so exhausting, this will undoubtedly affect the teaching and learning experiences of pupils within the classroom, and ultimately influence the pupils' decisions on which subjects to study at A level. Kyriacou reports on the heavy workload of teachers as a major source of stress which can undermine their effectiveness (Kyriacou, 2009, p.161). As this study will focus upon progression within post-compulsory physics education, the necessary statistical information has been provided by the Local Authority rather than the schools.

The data protection regulations were a major concern, as clearly it was necessary to ensure compliance. On several occasions, I was told that I could not access information for this reason, which subsequently affected the quantitative data that I was allowed to evaluate. I had originally intended to evaluate the number of students who studied physics A level over a longer time period, however, I found that the FEC does not keep records prior to 2001. I found this rather surprising as it prevents long term evaluations of trends in subject popularity. Despite this problem, I believe that the integrity of this study is not compromised.

Within the college, there was a lack of data relating to Higher Education destinations of previous students. I was surprised that prior to 2004, the FEC did not have any data relating to UCAS destinations. From 2004 to 2006, the data held were very minimal, such as the name of the student (which had been removed before I had access to the information), the institution and the course of study.

Whist researching the students' performance in modular A levels, it was disappointing to note the apparent lack of research by the examination board (OCR). Having access to OCR data on a wider data set of examination results would lead to a more thorough evaluation of any gender imbalances between modules, which would then determine whether any national differences between boys' and girls' conceptual understanding emerged. Having access only to data relating to the college confined this particular aspect of the study to a local evaluation.

Within the study, there are several occasions where the performance or attitudes of boys and girls are considered. It is important to distinguish the terms 'sex' and 'gender'. Sex refers to the biological differences between girls and boys, which can only be changed under surgery. Gender, on the other hand, is a socially constructed category which: 'describes the cultural and psychological expectations of behaviour' associated with male and female roles (Malik, 2003, p.5). The concept of gender, i.e. what is masculine and feminine, is more fluid in that it can change with culture as well as time. Early studies which explored differences in male and female achievement considered the differences between boys and girls from a biological stance. It was later found that the differences were due to the social and cultural influences that shaped the concepts of young people (Kyriacou, 2009, p.67). It must also be stressed that when referring to trends for a group, that they are not necessarily attributable to all members of that group.

Within the FEC, education for young people aged between the ages of sixteen and nineteen is provided by four designated Sixth Form Colleges, that are all part of the larger FEC organisation. It must be stressed that the FEC provides for all post-compulsory education within the city, and is not confined to Sixth Form education. Whilst each Sixth Form has its own ethos and strong links with their respective partner schools, the FEC maintains consistency of provision through shared schemes of work, resources and regular communication. Any references to 'the college' or the FEC will refer to the college as a whole and individual sixth forms will be specified by letters U, S, B or H where appropriate.

4.5 Ethical issues

> ‘Ethics refers to questions of values, that is, of beliefs, judgements and personal viewpoints. Central here is the question of responsibility. Responsibilities relate to the individual researcher, the participants in the research, professional colleagues and the teaching community, and towards the sponsors of the research.’
>
> (Hitchcock and Hughes, 1995, p.44)

The first consideration of the ethical issues was during the formation of the initial research proposal for this study. The Professional Doctorate study was undertaken whilst working at the FEC, and partly sponsored by this organisation so my first responsibility was to inform management of my intentions and discuss any potential ethical issues. According to Hitchcock and Hughes: ‘the design, execution and dissemination take on a higher profile when research is ‘financed’ or ‘sponsored’ or is in any sense under the direct control of some other person or agency’ (Hitchcock and Hughes, 1995, p.42). My proposals were discussed with senior managers at the FEC, however during the course of this study, there were several staffing changes within the senior management team, resulting in some differences of opinion. When discussing my reports with senior managers, there were some concerns regarding the work that I was conducting with external agencies, which I found surprising. One of my initial proposals involved a plan to interview or survey parents, however I was asked not to develop any strands of my research which would involve direct contact with parents.

The Ethics of Educational Research provides a definitive guide for all aspects of research within the teaching profession. It includes the full list of ethical guidelines from the British Educational Research Association. These guidelines are in distinct sections: respect for persons, the research profession, responsibility to participants, responsibility to the public, funding agencies and the host institution (McNamee and Bridges, 2002, p.251). These guidelines were adhered to throughout each study.

As the studies contained within the portfolio involved working with young people under the age of eighteen, informed consent was required for those students who directly participated in the study. At all times, students were made aware of the purpose of the study, asked if they were willing to participate and offered the option of not participating if they did not wish to do so. For the surveys (Sections 3, 5 and 7 of the portfolio), I provided a written summary of the nature of the research so that students could show parents. It was made clear that participants could withdraw from the study at any point.

The reasons for the surveys, discussions, case studies and focus group were explained to the participants. Sensitivity was important when conducting interviews, particularly when asking students questions about whether parents wanted more information about Higher Education. I checked all surveys with my line manager at the college prior to implementation.

One of the most significant constraints of this study was the issue of data protection. Throughout the study, names have been removed to respect the confidentiality of the participants. All notes and records were stored securely throughout the period of the study. All data obtained from the

Academic Registry of the college (e.g. UCAS data) had the names of the students removed before I was allowed to analyse the information. Similarly, when analysing examination performance, names were removed prior to analysis. Information provided by the Local Authority was based upon the Freedom of Information regulations, which also had to adhere to data protection requirements. Hitchcock and Hughes stress the importance of maintaining anonymity when conducting qualitative research in education in order to safeguard the rights and confidence of the participants (Hitchcock and Hughes, 1995, p.51).

When completed, each report was shared with at least one internal manager at the college who approved use of the reports within this study. In some cases, I was asked to remove sentences which were deemed to present the FEC in an unfavourable light. This was unfortunate as the statements were not aimed at the FEC directly, but were a wider criticism of the national political situation with post-compulsory education.

4.6 Reliability and validity of this study

As mentioned in the introduction to this chapter, this study has been conducted whilst I have been a practising teacher at the FEC, rather than an independent researcher. This can have advantages, as suggested by proponents such as McNiff (1993), McNiff and Whitehead (2007), who support the concept of educational research being conducted by practising teachers. It has several drawbacks, including the fact that, at times, I felt somewhat restricted in making criticisms of the institution or the wider political organisation of Further Education in the UK.

As a teacher at the FEC, I am in a position of trust, both directly due to my role as teacher or indirectly due to the relationships built up with students over a period of time. I have therefore had the opportunity to find out information that may be difficult for an independent researcher to determine. Hargreaves suggests that being a participant-observer eliminates potential resistance towards the research and 'permits the investigator to experience and observe the group's norms, values, conflicts and pressures' (Hargreaves, 1967, p.193).

According to Cohen: 'Quantitative research possesses a measure of standard error which is inbuilt and which has to be acknowledged. In qualitative data, the subjective of respondents, their opinions, attitudes and perspectives together contribute to a degree of bias' (Cohen, 2007, p.133). This is borne out by the fact that in the quantitative analyses of examinations (Section 4 of the portfolio), I used statistical methods and showed the accuracies with error bars on the graphs. With qualitative methods, it is more difficult, in fact impossible, to present a 'percentage error' calculation, so qualitative methodologies require a different approach.

Stake (1995) attacks the criticisms of qualitative methodologies in a very direct manner: 'qualitative study has everything wrong with it that its detractors claim'. He explains that this type of methodology is subjective, results in 'little advancement of social practice', ethical risks are higher, as well as costly in terms of time and money (Stake, 1995, p.45). By recognising these problems, qualitative researchers have developed respectable techniques for validation and an ethical obligation to minimise misrepresentation and misunderstandings. Stake suggests the use of triangulation in order to check that what we are observing and reporting has the same meaning when found under different circumstances (Stake, 1995, p.113).

Hitchcock and Hughes discuss triangulation in more detail, explaining that there are four main methods for triangulation. Data triangulation is when the investigation is repeated over a period of time with the same source, Investigator triangulation is when there is more than one observer involved, Theory triangulation is when there is more than one approach to the problem and finally, Methodological triangulation when there is more than one source of obtaining information (Hitchcock and Hughes, 1995, p.324).

From these four types of triangulation, methodological triangulation was employed within my study, as there were several occasions where I could cross check information by using different sources. For example, some of the responses from the focus group with students in Section 1 of the portfolio could be checked by confirming with other sources. The students provided factual information on the number of science teachers at their respective schools which was then checked with staff from these schools as well as with other students who were unconnected with the focus group. The consultant from the Institute of Physics worked with our partner schools and she further confirmed that the information the students provided was correct.

Hitchcock and Hughes suggest that one method for triangulating information obtained from interviews is to provide a transcript of the interview for the respondent to check in order to ensure that it is a correct representation. They suggest that a second interview may be useful to clarify any further issues or misconceptions. (Hitchcock and Hughes, 1995, p.182). When conducting the case study in Section 10, I provided the opportunity for the respondents to check and amend, if necessary, their responses to each question.

When conducting surveys and interviews, care was taken to explain to students the nature of the research. As the questions related to the topics and styles of teaching and learning they preferred, I have no reason to doubt their responses to these questions. When asking questions about family background, I interviewed each student separately. As this latter investigation was conducted with second year students, I had built up trust with them over an eighteen month period and met with most of the parents. I have discussed in Section 7 of the portfolio that due to the small number of students in this latter survey, it cannot be generalised and simply presents a representative sample of A level students at the FEC at that time.

Educational Research texts suggest that peer examination is another method of ensuring validity, by encouraging others to read, review and comment upon findings (Hitchcock and Hughes, 1995, p.325). This is borne out by the fact that each of the ten reports were reviewed by internal colleagues and managers at the FEC, as well as external professionals. I have included the original feedback forms in the portfolio, which show the suggestions, comments and opinions of the reviewers. I believe that adopting this process of peer review has helped to shape and improve the studies within the portfolio, but increased the validity of the body of work.

Cohen discusses external validity as the extent that results can be generalised to the wider population (Cohen, 2007, p.136). Clearly the findings from this study do not extend to those of all young people who study physics in post-compulsory education, only those who study within further education colleges. At this point in time, this is the only option for young people in this area unless they select faith or independent schools.

The fact that I was studying for a course at university in parallel with the students was surprisingly well received. Whether it was due to the fact that I could share my learning experiences with my students, or that I was striving to be a better teacher, the students were always very helpful and eager to participate.

4.7 Summary

This chapter has discussed the research design and methodology that has shaped each of the studies contained within the portfolio. By using a mixed methods approach, information has been collected from a range of sources in order to triangulate and ensure that the problem is approached from different angles and perspectives. It is also important to reflect upon the limitations of the work and the ethical considerations that needed to be taken into account when working with young people.

In Chapter 2 of this report, I refer to Brookfield's 'four lenses' through which we can view our teaching. I have used each of these four 'lenses' throughout this study, in order to gain a wider perspective and greater insight into the issues.

The first 'lens' is the autobiographical reflection, presented in Chapter 2 of this report, which discusses the main influences that have shaped my professional development, and the extent to which personal experiences have played an important part in shaping my career. Having devoted most of my career towards the teaching of physics, this has developed, and reinforced a very analytical and scientific way of thinking. The process of expressing my reflections in written form proved to be far more challenging than evaluating numerical data.

The second ‘lens’ is that of the students, which has been included throughout the portfolio in the form of focus groups (Section 1), surveys (Section 3), feedback (Section 5) and a case study (Section 10). At the end of the portfolio are further reviews by former physics students at the FEC.

The third ‘lens’ is that of our colleagues, so in order to achieve this feedback, I have ensured that each of the sections contained within the portfolio has been critically reviewed by at least two professionals with a particular interest in the topic. I have shared each section with managers (and colleagues) within the FEC, as well as sharing my work externally. Each section has been reviewed by a consultant or representative from an external agency in order to receive constructive feedback, as well as the opportunity of discussing and disseminating my research.

The fourth ‘lens’ is the theoretical literature, which has been presented in Chapter 3 of this report. The theoretical literature also supports each of the sections contained within the portfolio. Using each of these lenses should ensure that all perspectives are considered and lead to a valid and robust study.

The next chapter will consider the findings of each of the studies within the portfolio and the methods used to disseminate each of the reports to professional bodies.

Chapter 5 Findings from Research

This chapter will evaluate the findings from the studies contained within the portfolio in the context of the key research questions. The main objectives of the study were:

1) To explore the current levels of participation in post-compulsory physics education and consider why it is important to increase the number of young people who study physics.

2) To look at different strategies for engaging students with the study of physics in post-compulsory education and determine the impact that teachers can make on this engagement.

By considering each of the key research questions in turn, I will evaluate the extent to which these objectives have been achieved.

5.1 What is the current situation with the study of physics in post-compulsory education?

Within the portfolio, Sections 1 and 2 are concerned with the current situation of physics in post-compulsory education, with the former study considering the progression from GCSE to A level, and the latter study concerned with progression from A level to undergraduate degree study at university. Each of these studies is supported with reports from government agencies and professional institutions outlining the reasons why it is important to increase the number of young people who study scientific disciplines, as the skills developed can contribute towards future economic growth of the country.

Over the past ten years, the national number of school pupils who study separate sciences at GCSE has increased. From 1987 (introduction of the National Curriculum) until 2000, there was an emphasis upon balanced science in state schools, with many pupils opting for dual award science, or double science rather than the three separate sciences. In 2000, there were 979,826 candidates for the double award science course with 46,627 candidates for physics GCSE. By 2011, there had been an increase in the number of students who study separate sciences with 306,312 for the double science course and 140,183 for physics GCSE (JCQ, 2011). It is acknowledged in 'Taking Stock: The CBI Education and Skills Survey' that separate sciences provide the best preparation for developing STEM skills, particularly if young people wish to continue their studies to advanced level and beyond (CBI, 2008, p.29).

The national number of young people who study physics at A level has increased steadily over the past few years, from 28,096 (2008) to 32,860 (2011), which is a rise of 17% in three years (JCQ, 2011). Information provided by UCAS is presented in Section 2 of the portfolio, however since producing that particular study in 2010, the data for this year (2011) is now available and presented in a much more accessible manner than when the original research was conducted. The number of students on physics–related degree courses (as opposed to pure physics courses, F300) in the UK is 23,260 in 2011, stating that this is an increase of 17.8% upon the applications in 2010 (UCAS, 2011).

At this point, one may begin to question why this is a key research question, since the national numbers for GCSE, A level and under-graduate physics courses appear to be increasing. When compared to other science subjects, however, one can see that physics is the least popular of the three main sciences, yet a degree in physics can develop a range of technical, mathematical, problem-solving and analytical skills which are of interest to employers. As outlined on the Prospects Website, physics graduates develop skills which are applicable to a wide range of careers. Ironically, of the physics graduates in 2010, business and finance was the single most popular graduate career (Prospects, 2011).

At A level, chemistry (48,082 candidates in 2011) and biology (62,041 candidates in 2011) have far more candidates than physics (JCQ, 2011). At university, chemistry (24,159) and biology (28,846) also attract more students, although it is more difficult to compare university data due to the wide variety of associated degree courses, both pure and vocational (UCAS, 2011).

Whilst it is clear that on a national level, physics is not as popular as chemistry or biology, it is a fact that may cause some concern, but may not warrant a key research question. At the FEC, students generally select physics A level in combination with mathematics and either chemistry or computing, following a clear career pathway. Within biology and chemistry A level classes, students combine these with more diverse range of subjects such as psychology, sport, mathematics, sociology etc. Therefore the fact that fewer students study A level physics than biology or chemistry is not a great cause of concern.

Through the Local Authority, I determined the numbers of pupils from schools within the city who were following courses in GCSE physics, and this mirrored the national trend, particularly with the proportion of girls who had selected to study the subject. So far, the situation appears to be quite positive, however the reason this question was initially framed was that the encouraging national data was not correlating with the numbers of students choosing to study A level physics at the FEC.

As mentioned in Chapter 2, I moved out of the physics team and into a pastoral role between 2001 and 2006. During this time, the number of A level students at the college decreased markedly, to a minimum in 2003[1]. When I returned to the physics department, I was quite alarmed at how the subject had decreased in popularity and I was determined to 'revive' the subject.

Since returning to the physics department, A level physics has consistently achieved the strongest examination results of all three sciences[2] Whilst I would like to attribute these good results to the quality of the teaching, my personal opinion is that it is not related to technical expertise but due to the empathetic approach in which I try to bring out the best in each student. I would strongly suggest that the improvement number of students who study A level physics, along with the improved examination results, corroborates the work of Hargreaves (1997), who discussed the emotion of teaching and Cooper (2011), who discusses the importance of empathy in teaching.

On returning to the physics team, I was also concerned to find that despite good results, very few of our students progressed to study physics degrees at university. Out of this rather personal perspective of the situation,

[1] There were 77 AS students at the FEC in 2000/1, decreasing to 37 in 2002/3, then fluctuating but reaching 80 in 2011/12.
[2] 100% success rates (retention x achievement), for the past 7 years

framed within the confines of a city in the north east of England, I began the doctorate programme. This was not the start of my concerns, simply the start of a more formal method of investigating issues that had been of concern for many years.

Over the course of the programme, however, I became increasingly aware of the vast political frameworks that support and undergird the education system, particularly in the post-compulsory phase. Whilst I was aware of the problem in attracting girls to the study of physics, which was to be the next key research question, I was more surprised at finding an emerging social class issue with the study of physics in post-compulsory education. At the time of formulating the key research questions, this had not been a very significant factor, as I was locating the study within a specific FEC with a widening participation agenda.

Returning to this key research question, I found that a focus group with A level students was particularly revealing (Section 1 of the portfolio). This group comprised A level students at the FEC who had chosen to study science A levels, but not physics. From this study, it emerged that within our partner schools, there is a serious lack of specialist physics teachers and that pupils are taught physics (up to and including GCSE) by biology or chemistry teachers. The students claimed that the subject content at GCSE was rather dull, as it was mainly going over topics that they had been taught in previous years at school, rather than bringing in new content. The students in the focus group had combined chemistry and biology A levels with either mathematics or psychology, with the intentions of studying medically related disciplines at university. Clearly they had decided that physics was not necessary for their future career intentions, but they admitted they would have considered the subject if they had not been largely influenced by the lack of enthusiasm (or personal qualities) of the teachers who had taught them physics at school. (This is strongly interlinked with key research question 3). Osborne and Collins found a similar situation when they conducted their research in that: ‘the importance of the role played by the teachers in stimulating and maintaining pupils’ interest in science was raised unprompted by pupils in every group’ (Osborne and Collins, 2001, p.459).

When I asked the Heads of Science from our partner schools why they thought there was an issue with progression to study A level physics, I received comments about the ‘rather dry’ nature of the course, and that the current physics GCSE specifications is not interesting to teach. This highlights the point that the enthusiasm of the teacher is of prime importance, particularly if the teachers do not have physics backgrounds, and are being made to teach subjects outside of their personal expertise. Once again, the enthusiasm of the teacher, for both the subject and the students, is paramount, and when teachers enjoy teaching their particular subject, they can motivate students far more than teachers who do not show enthusiasm (Muijs and Reyolds, 2005, p.110).

Having established that there is a shortage of specialist physics teachers in our partner schools, further research revealed that when local schools are recruiting new science teachers, there are far more applicants who specialise in biology than either physics or chemistry. This is an extrapolation of the fact that there are far more biology graduates who are trained as science teachers than from physics or chemistry backgrounds.

The Set for Success Report (2002) claimed that physics graduates were more likely to work in the financial sector, whereas graduates in biology were more likely to work in education (section 1.15).

As mentioned earlier in this section, with such a wide choice of careers open to physicists, teaching is not the most financially rewarding profession. It is pertinent at this point to state that if a teacher chooses to work in a secondary school within the city (teaching up to GCSE) they will earn considerably more than teachers in the FEC who teach A levels. This is ironic as there are a number of science teachers at the college who are educated up to PhD level, but they must move to less academically demanding jobs if they want promotions or increased salaries. Clearly this leads to recommendations which will be discussed in the next chapter.

Returning to the key questions, what have I been doing to increase the number of young people who study physics at the college? Over the past two years, I have worked with the Stimulating Physics Network consultant, who has been assigned to support non-physics teachers within secondary schools who are required to teach physics. We have worked together over the past two years and arranged Teacher Training sessions for physics to be based at the FEC. In July 2011, I organised a one day physics event (The Ashfield Music Festival) which was designed to engage and inspire pupils from our partner schools, and raise the profile of physics education. The event included representatives from STEMNET, engineering undergraduate students, teachers from our partner schools, current A level students and also Connexions Advisers. The event was in the form of a competition and proved so successful that we are intending to hold a larger event later this year.

With regards to the progression of students to physics degrees at university, the underlying social class factor becomes more apparent. In the north east of England, there are five universities, of which there is only one where students can study physics degree courses. This particular university is highly prestigious and very selective, requiring A grades (and one A*) at A level. There is one Russell Group university within the region, but it ceased teaching physics ten years ago due to a decrease in popularity of the subject combined with the expense of the equipment required for teaching the course. The other three universities do not offer physics, but a wider range of vocational courses associated with engineering.

The availability of physics degrees within the region, or lack of them, is particularly important for working class students, many of whom are the first generation of their family to progress to Higher Education. Many of my students who have shown great promise and aptitude for physics have chosen to study other subjects (Natural Sciences or Chemistry) rather than move away from home to study physics. Whilst my study is based within the north east of England, I have subsequently found from the Institute of Physics (National Network Co-ordinator) that the problem is not confined to this region, but extends across the whole of the UK. The problem was phrased as ‘the physics deserts’, to explain the areas of the UK where physics degrees are not offered, which presents a problem for working class students who live in these regions and cannot afford to move away from home. The Co-ordinator explained that the IOP were aware that in recent years, students are very unlikely to move more than 50 miles from home, and that availability of a degree course in a geographical area was an important factor for selecting a degree subject (Physics Desert Problem).

From my studies, I have found that the only students from the FEC who have progressed to study physics at university over the past ten years have been from middle class families (7 students). These students have been provided not only with financial support, but also with the emotional support and encouragement that is necessary to move away from home. These findings are supported by the studies of Reay et al (2001) who suggested that working class students chose local universities as there are not only financial factors that affected choice of university, but emotional constraints. Reay et al (2005) further developed the theory of social class and choice of university, finding that working class students tend to opt for 'new' universities so that they can live at home and remain part of the family unit. This will be discussed further in section 5.5 of this chapter.

In order to quantify this point, HESA provided me with (some) information relating to physics undergraduates in the UK. In 2009/10, there were 12,880 undergraduates studying physics, of whom 1,535 came from privately funded schools (11.9%) whereas the national proportion of undergraduates from the private sector is 6.1% (HESA, 2011). The higher proportion of students from private education who proceed to study physics degree courses could arguably be a consequence of fewer working class students progressing to study physics at university.

Information relating to social class is not available on the HESA website. After explaining the purpose of my research, they provided some limited information free of charge. I found it quite alarming that data relating to social class was not freely available through either UCAS or HESA, despite both websites offering statistical information sections. Both organisations required fees for each search question, which would deter individuals from being able to afford to conduct meaningful research. At a time when tuition fees are set to reach the new higher levels, it seems particularly important to study the accessibility of university education by different socio-economic groups.

In order to pursue this line of research, I asked the institute of Physics if they could provide further information and they sent data (which they had previously commissioned) of the parental occupations of first year (UK) physics undergraduates (see Table 5.1 on page 154). It is difficult to extract meaningful statistical data from this table due to the high number of 'unknown' or 'not classified' respondents (in 2008/9, there were 1450 who fell into this category). It can be seen, however, that as social class increases, so does the number of students from those families. It would not be possible to draw any further inferences due to the inability to compare with other disciplines.

TABLE 5.1

Parental Occupations of UK First Year Undergraduate Physics Students

Parental Occupation	2004/05	2005/06	2006/07	2007/08	2008/09
Higher managerial & professional occupations	825	815	845	1045	985
Lower managerial & professional occupations	845	825	829	945	890
Intermediate occupations	410	415	355	405	435
Small employers & own account workers	165	165	140	140	145
Lower supervisory & technical occupations	125	135	125	115	130
Semi-routine occupations	265	250	255	265	315
Routine occupations	100	100	95	105	110
Not classified	375	525	495	535	710
Unknown	490	605	585	575	740

(HESA, 2010)

Returning to the key research questions, what have I done to try to address this problem? Over the past few years, I have liaised with STEMNET to introduce more STEM Ambassadors to the college, who not only provide information about careers, but provide valuable role models for our students. I have linked with the science departments of local universities and worked with employers in the area to encourage strong networking and useful contacts. I have made a careers notice-board in the laboratory which highlights the range of professions open to physics graduates. I have made displays of successful students to show what students can achieve with physics and engineering degrees.

To summarise: On a national level, there seems to be an increasing number of young people who choose to study physics at GCSE, A level and at university. On a local level, this is quite different. There are healthy numbers of students who study GCSE physics within the city, with the schools addressing the need for good science education. Without continually working at raising the profile of physics, the numbers who progress to A level physics are at risk of falling, which is borne out by the data for the FEC. Even with increased numbers of students, and excellent success rates, there is still a problem with encouraging students to progress to physics related degree courses. The data reveals one obvious further factor, in that there is still an under-representation of girls in physics, which will be discussed in 5.2. The exploration of classroom strategies will be discussed in 5.3, with examination performance in 5.4 and the wider external influences in section 5.5 of this chapter.

5.2 To what extent is there a gender imbalance within physics?

Sections 1 and 2 of the portfolio address this question, however the issue of gender imbalance is threaded throughout each of the studies within the portfolio. It is pleasing to note that the gender imbalance at GCSE has been largely addressed, both nationally and regionally, with a good proportion of girls studying GCSE physics. In 2011, 46% of the candidates for GCSE physics were girls, with a healthy 64,526 girls taking the subject and 75,657 boys (JCQ, 2010). Within the city, the number of candidates for GCSE physics in 2010 was 424, of which 184 (44%) were girls, showing that the local data mirrors the national data (Local Authority).

The gender imbalance within physics begins to emerge at A level, with the national proportion of girls studying A level physics decreasing gradually over the past three years (22.2% in 2009, 21.5% in 2010 and 20.8% in 2011). Compared with chemistry A level (47% female candidates in 2011) and biology (56% female candidates in 2011), there appears to be an issue with the progression of girls into physics A level, whereas there does not seem to be the same problem with either chemistry or biology (JCQ, 2011).

Within the FEC, the proportion of girls who study physics is less than the national figure, with only one girl out of 23 A2 physics students in 2010/11 (4.3%), and one girl out of 22 (4.5%) for the cohort who are to take A2 physics in 2011/12. Through a very strong effort of working with our partner schools, (science taster sessions, visits to the schools, meetings with teachers and staff, as well as the events organised with the Stimulating Physics Consultant), we have increased the number of new AS physics students for 2011/12, and also the number of girls who are studying AS physics, which is now 20/80 (25%). (These students will be taking their A2 examinations in 2013).

From the focus group that was held with A level students who had chosen to study science subjects but had not chosen physics (discussed in 5.1), it emerged that not only was there a shortage of physics teachers, but an even greater shortage of female physics teachers. None of the students in the focus group had been taught physics by a female teacher, which suggests they have not had the benefit of strong female role models.

The importance of role models was further explored in Section 7 of the portfolio, as I learned more about the importance of this contributory factor. Through studies such as Booy (2009), who claimed that girls have very little awareness of what careers in science involve, I could then appreciate why pharmacy was a popular choice for students at the college. For most of the students at the FEC, a pharmacist is their projection of a 'scientist', possibly the only type of scientist they have had any interaction with. The students have a sound understanding of what a pharmacist does on a day to day basis, the environment in which they work and how they look, act and present themselves as professionals. The importance of role models is discussed in more detail in Section 3.3.4 of this report (Bettinger and Long, 2004, Cruess, 2008).

The students in the focus group commented that some of their physics teachers at school were lacking in interpersonal skills, although this was expressed in their own vocabulary. In the Literature Review (Chapter 3, Section 3.3.1 of this report), I have discussed the fact that often science can attract particular personality types. For example: 'Opting for science will permit and possibly reinforce emotional reticence' (Head, 1987, p.17). Clearly, this type of personality is not well suited towards a career in the teaching profession.

Whitelegg states: 'There is some evidence that science teachers show less leadership, friendliness and understanding towards students than teachers of other subjects' (Whitelegg et al. 2006, p.24). She quoted a Canadian study (Haggerty, 1995) which claimed that female science teachers were better at relating to students, due to women's 'feelings of being connected to others' (Whitelegg et al., 2006, p.25).

Section 3.4.3 in this report discusses the emotional demands of teaching, with authors such as Noddings (1992), Nias (1996), Hargreaves

(1997) and Cooper (2011) each developing the importance of the empathy required within the teaching profession. Whilst these studies are generic and relate to all disciplines, the fact that many physics teachers lack empathy is an important point and must be incorporated into teacher training courses for physicists.

Whilst provisional data relating to UCAS applicants in 2011 is now available, it does not include a gender analysis, therefore data relating to 2010 must be used instead. The proportion of girls who studied physics degree courses (F300) was 20.5% in 2010, which is less than chemistry (F100) with 39.4% female applicants. It was noted in the report in Section 2 of the portfolio that other branches of physical science held a greater attraction for girls, for example, the proportion of female applications for astronomy was 30%. The branch of physical science with the greatest proportion of female applicants (66%) was forensic and archaeology sciences (UCAS, 2011).

The popularity of astronomy strongly correlates with the academic research in the Literature Review, such as Osborne and Collins (2001) who found that space was the most popular scientific topic within their study: 'The universal success of this topic should not be underestimated as a valuable point of engagement with science' (Osborne and Collins, 2001, p.457). Stewart (1998) as well as Whitelegg and Murphy (2006) found that girls are attracted towards those branches of physics that have humanistic components, so this may be the reason for the attraction of forensic science. It could be argued that opening up the science specifications at GCSE and A level to incorporate some of the wider applications of science could increase interest and motivation for all learners.

As I have discussed in Chapter 2 of this report, it was an attraction to astronomy that fired my own interest in science, so I can appreciate why this is a very important and significant topic. The appeal of astronomy suggests an emotional engagement with the topic that encourages a sense of wonder and awe, as well as firing the imagination of young people. As a teacher, astronomy can be quite different to teach than any other topic within physics, as it naturally leads to more discussions, more questions and a social learning environment. Whilst astrophysics at degree level is highly mathematical, at GCSE and A level, the mathematical components of astronomy are not particularly demanding. Astronomy, as a science, is accessible to a wide range of ages and abilities, as well as being the most popular science for amateurs. The popularity of astronomy was also highlighted (for boys and girls) in the survey that I conducted as part of the Action Research Project (Section 5 of the portfolio).

The national data does not reflect the local situation, for it is increasingly more difficult to encourage girls from the FEC to study physics at university. Over the past ten years, there has only been one girl from the FEC who has chosen to study a physics related degree course of study. Following an interview with this young woman (Section 10 of the portfolio), it reinforced the importance of two important factors: social class and role models. This young woman came from a well educated family, where both parents were mathematics teachers, one of whom lectured at a university. The study of a strongly mathematical degree subject was an expectation for this young woman, rather than an aspiration, with both of her parents providing strong, first hand role models.

With all four of the case studies (Section 10), all expressed a strong interest in astronomy and that was the main attraction of studying physics. This seems to be a great ‘hook’ into physics for young people, and as mentioned earlier in this section, correlates with a greater proportion of girls who study astronomy at university than pure physics courses.

All four of the women case studies (Section 10 of the portfolio) were from middle class, well educated backgrounds. This may be a coincidence, as four examples is clearly not a representative sample. Perhaps it is due to the fact that students from middle class families may be more financially as well as emotionally prepared to move away from home in order to study for a degree. When interviewing the young women for the case studies, none of them believed that they had faced any unfair treatment for being female. However, concerns were expressed that in order to develop a career in astrophysics, they had to be geographically mobile, not just nationally but on an international scale. The travelling itself was not a problem, it was that post-doctoral study took place between the ages of 24 to 35, which coincides with women’s main childbearing years. The women in the case studies believed that it would be difficult to develop a career in astrophysical research and start a family at the same time, but were fully intending to make the best of all opportunities in life as they were presented to them.

Whilst the four women in the cases studies were all from middle class backgrounds, the situation is different for girls from working class backgrounds. Evans (2009) studied the choices of working class girls and found that family responsibilities led to them choosing to study at the most local university. This will be discussed further in this chapter (5.5) as the issue of class is one of the wider social factors.

Returning to the key research questions, what have I done to try to address this problem? I would argue that the initiatives that I have developed are to encourage all students, not just girls. I have made a conscious effort to find female role models and to include more of a humanistic approach to physics. As Murphy and Whitelegg stress, however, any classroom strategies developed for girls also have a positive impact upon the education of boys (Murphy and Whitelegg, 2006, p.28). I have found this to be very true, and that one can never make assumptions about groups.

5.3 Can teaching and learning strategies in the classroom encourage more young people to study physics?

The report ‘A degree of Concern’ (Royal Society, 2006) outlined some of the factors that influence student choice in post-compulsory education:

a) Curriculum structure
b) Curriculum content
c) Range of subject options
d) Dynamic subject specialist teaching
e) Quality of careers advice
f) Students’ and their families socio-economic background
g) Perceptions of science and scientists such as those promulgated by the popular media

h) Relative subject difficulty

(Section 4.1.1)

Curriculum structure (a) and content (b) both emerged as important points from the focus group in Section 1 of the portfolio. The range of subject options (c), the influence of family (f) and the media (g) are all discussed in Section 7 of the portfolio. Careers advice (e) was discussed in Section 9 of the portfolio. Relative difficulty is discussed in the literature review of this report (3.2.3). Only one of these factors from the list of eight possible influences is directly related to the classroom teacher. This is surprising, as I would have expected a good teacher to be able to contribute towards the other factors and dispel misconceptions. On the other hand, one of the fundamental reasons of conducting this study is due to the wide range of other factors which influence student choice. This dilemma led to Key Research Question 5, which is discussed later in this chapter.

Within the portfolio, sections 3, 5 and 6 specifically addressed this key research question, exploring methods of engaging young people with physics education in the classroom. Whilst some of the issues with physics education must be resolved on a national level, the enthusiasm and commitment of the practising physics teacher is paramount, not only for achieving the best possible grades in examinations, but also for inspiring young people to take the study of a particular subject to the next level of the educational ladder. According to Hattie (2003) in 'Teachers make a difference', teachers are the single most important influence upon how a student connects with a subject.

It was also shown from the focus group in Section 1 of the portfolio that the teacher was a very important factor for how much a student engaged with a subject. Osborne and Collins (2001) stated that when conducting research into attitudes towards science education, pupils would often discuss the teachers. Within Chapter 3 of this report, I discuss the importance of good physics teaching (3.2.2). It is important to note that whether the literature is specifically associated with physics education, or more generic in origin, subject knowledge is rarely raised as an issue. Good teaching is not necessarily associated with how much a teacher knows, but how much they can convey their enthusiasm to young people. Kyriacou claimed that teacher enthusiasm is one of the most important variables in what actually goes on within the classroom (Kyriacou, 2009, p.8). Cooper suggests that a teacher's enthusiasm and energy is infectious and can produce a 'mirror response' in students (Cooper, 2011, p.122).

Under this Key Research Question, however, my original intention was to focus upon classroom methods for engaging students with physics. The following initiatives were devised to try to encourage and inspire students, as well as motivate students to achieve the best grades possible. It must be said, however, that it is impossible to totally separate the teacher from the activities.

5.3.1 The use of surveys to engage in educational dialogue

As part of this study, I have used questionnaires to determine the preferences of my A level physics students, whether subject content or learning styles. The aim of these questionnaires was to promote dialogue, as suggested by the Institute of Physics document: ‘Girls in the Physics Classroom’ (Hollins et al., 2006). By the age of sixteen, many of the students within my A level classes had already established their ‘comfort zones’ of preferred learning and were often reluctant to embrace new ideas. A growing concern was that many of the students had specifically chosen to study physics (and mathematics) not because they enjoyed the subject, but because they were under the impression that these subjects required the least amount of writing. Therefore, whilst conducting questionnaires, I was always mindful of Brookfield’s advice that students who define their needs as never straying beyond their comfortable ways are not in the best position to judge what is in their best interests (Brookfield, 1995, p.20).

For the investigation into learning styles, my second year A level students indicated that their preferred activity was doing calculations along with problem solving activities and practical work. Activities such as making posters, presentations (or notes) were least favoured. As these students were holding university places which required high grades, they were anxious for teacher-led lessons, consisting of teacher exposition, practical work and followed up by calculations, problems and examination practice. The prospect of going to university seemed to provide a motivating force for encouraging students to work hard and achieve the best grades possible.

When I gave the same survey to first year A level students, the results were more diverse, although presentations again emerged as one of the least valued classroom activities. The first year students preferred activities such as making posters, working in small groups on problems, and discussions. When I separated the responses from the girls to see if there were any gender trends in preferred activities, the only aspect where the girls were unanimous was in their preference for doing calculations on their own. The only difference that emerged was that the girls were quite positive about making notes, whereas this generated a very negative response from the boys.

Calculations are popular with boys and girls, from both first and second year A level physics students. It seems ironic that I was told by a more senior manager to take out any references to calculations from a physics factsheet in case this deterred students from applying for the course. Coming from a different subject discipline, this manager thought it impossible that prospective students might be attracted to a subject with calculations. The appeal of calculations can be counter-productive, however, as this may simply be in preference to, or mask weaknesses in written communication.

Coffield conducted research into thirteen learning styles used in post-16 education and states that ‘the primary responsibility of teachers and trainers is to maximise the learning opportunities of their students’ (Coffield, 2004, p133). Whilst he considers each style in a respectful manner, in the conclusion, he is critical of being overly concerned with learning styles: ‘Why should politicians, policy-makers, senior managers and practitioners in post-16 learning concern themselves with learning styles, when the really big issues concern the large percentages of students within the sector who either drop out or end up without any qualifications?’ (Coffield, 2004, p144)

After conducting surveys with my students, my conclusions were that all students are unique and it would be impossible to make any generalisations about a subject or a particular class. A good teacher (of any subject) must recognise the variety of learners within the class, produce interesting lessons with a range of activities to enhance and engage students (Murphy and Whitelegg, 2006, p. 28). Above all, a good teacher must convey enthusiasm for the subject (Kyriacou, 2009) and empathy with the students (Cooper, 2011).

5.3.2 Project Think!

This project involved the development of activities to stretch and enhance higher order thinking skills, which formed part of an inter-disciplinary project at the FEC. While working for this project (Project Think!), my first contributions were based upon problem-solving scenarios, although I became more interested in exploring resources that would develop students' abilities to work through multi-stage problems, particularly those which required extended concentration and the synthesis of several concepts.

One of the benefits of working in a cross college project is that you can work with teachers from other disciplines. This leads to the sharing of techniques and strategies, often finding fresh approaches that you can tailor to meet the needs of your students. The sociology teacher had devised some fun activities for developing students' verbal communication, which I adapted for my students so they could develop the use of appropriate scientific terminology. Similarly, the philosophy teacher provided some interesting activities based upon 'How do we know?' which I adapted for my students to stretch and challenge their understanding of scientific knowledge.

Discussing teaching and learning with teachers from other subjects also helps to raise the awareness of common problems, for example the issues of weak written communication skills and 'bite-size' concentration were raised by all of the A level teachers who participated in the project and recognised as barriers to student success. Within Chapter 2 of this report, I have discussed the problems with the low concentration spans of many students. Hayes et al. refer to contemporary post-16 learners as 'McStudents' who want 'easily digestible McNuggets of knowledge' (Hayes et al., 2007, p.50). Steinborn has conducted psychological investigations into concentration and believes that the ability to sustain and regulate focus over extended periods of time is crucial to academic achievement (Steinborn et al., 2008, p.614).

The Teaching and Learning Co-ordinator also lectures on the Teacher Training programmes within the college, so she seemed a suitable person with whom I could discuss my work. As this lecturer has an academic background in social sciences, she raised the issues of validity and reliability when conducting research into education (see section 4.6 of this report).

The resources that were produced for the project were collated, although not published or disseminated according to the original proposals. Since producing this report, however, I have been invited to publish this report in a FEC based journal which will outline all of the recent research projects that have been undertaken at the college.

5.3.3 The action research project

This involved the development of the college Virtual Learning Environment (Blackboard) to make it more accessible for students and encourage them to share their work through the use of blogs and wikis. This initiative was conducted after the study into examination performance, as this revealed a need to develop students' written communication skills. One of my main objectives for this project was to encourage students to write more frequently, whether as part of an online diary, revision notes, or topics they were interested in beyond the confines of the specification. Another objective was to encourage students to use the vast range of resources available on the VLE by using it more often, particularly when they were at home on evenings or weekends.

As this project was conducted in conjunction with the Science Learning Centre, I was required to produce a set of specific measurable outcomes in order to evaluate the success of the project. The factors chosen were:

1) To improve the pass rate of the AS physics class
2) To improve the progression rate from AS to A2 physics
3) To encourage more students to apply for physics related degree courses.

There were two qualitative methods of assessing the outcomes of the project, first by a survey to determine students' opinions and secondly by comparing written work conducted at the start of the course with written work produced one year later.

The action research project required attendance at three training sessions and each session was well structured, very supportive but above all, allowed the opportunity to reflect upon classroom practice with other physics teachers. Recent professional development at the FEC has concentrated upon generic teaching skills, rather than subject specific training. Due to the structure of the FEC, subject teachers work very much in isolation, therefore the opportunity to discuss ideas with other physics teachers proved very valuable indeed.

In June 2010, I was asked to present my findings with a group of Science Learning Coaches at the regional Science Learning Centre. The coaches were from differing science subjects yet all agreed that students had difficulties in expressing ideas in good written English. There was general accord that the current GCSE misled students into thinking that written communications were not necessary for science.

At the end of the project, when the examination results were published, I completed the report. During the academic year 2009/10, I taught two AS physics classes, one at my home sixth form centre where I had worked for four years, and a class at another centre where I replaced a teacher who had left the college. At my home centre, the success rate increased by only a small amount (78 to 80%), whereas at the second centre, the success rate increased from 57% to 83%. As mentioned earlier in this chapter, it is difficult to separate the teacher effect from the activity. It could be argued that the improvement was not necessarily the project, but due to the different teacher. The progression rate improved, as well as more students applying to study physics related courses at university. For the first time in several years, it was pleasing to see that 6 of the 14 physics (A2) students were applying to study physics related degree courses.

The analysis of the written work before and after the project provided the most striking differences, showing improved use of advanced scientific vocabulary and terminology. After completing the project, I sent the report to the Director of Resources at the FEC, who provided very positive feedback. He suggested that the JISC Excellence Gateway may be interested in my work, as it demonstrates a means of engaging students outside of the classroom simply by using what is freely available within the college. I met with a representative from JISC in November 2010 and my report was published on the Excellence Gateway website (March 2011) at the following link:

http://www.excellencegateway.org.uk/page.aspx?o=314664
(Excellence Gateway, June 2011)

The Professional Development Leader from the Science Learning Centre provided an external evaluation upon completion of the report and uploaded a shorter version onto the Science Learning Centre Portal.

Through this experience, I have actively promoted Action Research Projects within my team, as I believe that projects formalise the efforts that teachers put into practice on a daily basis. There have been two other ARPs conducted by members of my team in the past year, one to investigate mathematics bridging courses to help with the transition from GCSE to AS level study, the second study investigated the embedding of QR (Quick Response) codes into assignments.

5.3.4 External curriculum support

There are a wide range of support agencies available for teachers as well as students, to encourage, develop and extend science education beyond the classroom. For example, STEMNET is the largest national network that provides activities for young people, whilst the Science Learning Centres provide support for teachers. There are other subject specific support agencies such as the Institute of Physics. I was aware of many of these services prior to the professional doctorate study, and have participated in numerous events that were organised by these agencies. Through this study, however, I have met and worked with several representatives from these organisations and 'networking' has proved advantageous for my colleagues in the science department as well as supporting the students.

When designing the doctoral study, the intention was to share my work and receive evaluations from at least one person within the FEC and other external professionals who would have a particular interest in my work. Through this initiative, I made contact with a consultant from the Stimulating Physics Network (Institute of Physics), and as mentioned in 5.1, we are working together on initiatives to support physics education in our partner schools.

Joining networks such as 'Talk Physics' (talkphysics.org) allows daily conversations with physics teachers from other establishments, sharing ideas as well as our problems. Due to the structure of the FEC, many teachers (A level) often work in isolation, so this forum provides a useful platform for connecting with other teachers. Some of the topics asked by the physics teachers include sharing ideas for inspirational taster lessons, how to teach particle physics in a more active or practical manner, or what is involved in a Head of Physics role. I have recently been informed by the IOP that the forum has proved so successful that the initiative will be taken up by other subjects within the next year.

When investigating agencies such as WISE, making personal contact has enabled greater communication, stronger links between the establishments, as well as copious free literature and information for our students. Working with STEMNET has ensured that I am fully aware of all the opportunities that they can offer, which I can disseminate to staff as well as students. When I informed STEMNET of our intentions to present the Ashfield Music Festival physics event, they sent along two engineering undergraduates as STEM Ambassadors. This involved leading teams for the one day event as well as making a presentation on the different types of engineering degree.

The STEM Ambassador scheme allows professionals from STEM professions to visit schools and colleges. This is an excellent service as STEMNET takes care of the organisation of the scheme. This year, I have arranged a number of visits to the department by STEM Ambassadors who have not only explained the application of science to real life situations, but acted as role models for our students. Some of the ambassadors this year have included an engineer from International Paint, an astronomer and a geophysicist.

Whilst I have developed many strategies to engage students throughout my career (for example: science clubs, science quiz teams, revision evenings and for many years, co-ordinated work experience for our students), the three initiatives above were investigated as a component of the professional doctorate programme. As each classroom initiative was evaluated, it was always difficult to extract or measure the extent to which students were contributing in order to help me as a person or as a teacher. They liked the fact that I was studying a course in parallel to their studies, and that I openly discussed how I wanted to develop my teaching so that they achieved the best grades possible. Some of the students liked the idea that I shared their work with the Science Learning Centre, and maybe the fact that I care (and am relentlessly enthusiastic) about my students and my teaching was more important than the actual strategies themselves?

5.4 Can examination performance reveal any key differences between how boys and girls learn physics?

This key research question was explored in Section 4 of the portfolio, which began by comparing the examination results of each of the six physics modules that comprise the A level physics course. Contained within this study, is the issue of re-sit examinations, as students have the opportunity to re-sit as many times as they wish in order to achieve the best grade possible. This study could be regarded as a separate 'stand alone' investigation, but has been integrated into the portfolio as it revealed issues about engagement with the subject and the importance of written communication skills. The first study was conducted after the 2008 examinations and it showed that whilst girls often asked to study the health physics option at A level, as they were interested in this topic, it did not lead to better examination results, in fact the converse was true in that it often led to students' least successful modular result.

Earlier studies by Jones and Kirk (1990) and Stewart (1998) indicated that girls prefer the more humanistic aspects of physics, but from my study, I found that the main reason why students (both girls and boys) fared less well with this module was the amount of writing and explanation style questions contained within this paper. Therefore it was not as much an issue with content as with the underlying written communication skills required for this particular examination.

The problem of written communication in the health physics examination was not confined to the FEC, it is a national problem. It was noted in the Examiner's Report (2008) that 'A number of good candidates are still failing to achieve in the extended answer questions'. Despite devising a range of resources and classroom activities to promote and develop extended writing skills, many students expressed a clear dislike of this type of learning, preferring the numerical aspects of physics.

As discussed in the Literature Review (Chapter 3), Bernstein linked verbal and written communications with social class and claimed that, in general, working class children had less well developed vocabularies than middle class children. He claimed that children from working class families had a 'restricted code' of speech, which was: 'not so much in the genetic code but in the culturally determined communication code' (Bernstein, 1971, p.151). This study could be extended to compare with students at the FEC, for whilst some of the students could understand the physical principles in order to perform calculations, expressing ideas either verbally or in writing presented greater difficulties. Whilst it was outside of the confines of this study, it was interesting to draw upon the work of Bernstein and take particular interest in the vocabularies of students and how this was related to social class.

Throughout this study, there were some very obvious cases where middle class students exhibited greater vocabularies and grammatical abilities than some of the working class students, with more confidence at expressing answers either verbally or in writing. It must be stressed, however, that Bernstein's theories are generalisations, and not to be assumed to hold true for all students. Two of the highest achieving students from this particular study were both from socially disadvantaged backgrounds, yet both worked hard to achieve academic success. Both students demonstrated excellent written communication skills yet both were both weak with verbal communication. They used a form of 'restricted code' of speech as described by Bernstein (1971). These two students both achieved grade A for physics A level and progressed to Russell Group universities. This clearly shows that whilst home background is one factor that contributes towards achievement, it is combined with a range of other influences.

Having studied six years of data, I found that there were no particular modular examinations where girls and boys average (mean) marks differed. The trendline for the girls mirrored the line for the boys, showing that both groups performed in a similar manner, with no apparent differences in examination performance. McClune (2001) found that boys tend to take advantage of the modular nature of A levels, and my studies have corroborated his findings with the evidence of seven years data showing that boys take far more re-sits than girls (the mean number of re-sits for boys was 3.5, whereas for girls was 2.6). Some boys extended their studies over three years in order to achieve the best grade possible but none of the girls extended their studies.

After conducting the first study, I posed the question to the physics team at the FEC of whether students should be allowed to study an optional module as part of their physics A level study. We asked ourselves what was more important, to engage students with a topic they are interested in, or examination success? Whilst some of the students (boys as well as girls) would have preferred medical physics as they were intending to study health-related careers, they were just as happy to study astrophysics, for the reasons outlined earlier in this chapter.

Through this particular study, I have used statistical data to drive improvements in our examination results. Exploring student performance in the optional modules has made teachers far more aware of the need to think carefully of the implications of re-sit examinations. By sharing the findings with students, they have developed statistical tactics for re-sits and explored which will yield the greater possible increase in marks. For example, some students reach a conceptual ceiling with their A2 studies, but find they can achieve a grade C at A level by re-sitting first year modules and combining high AS marks with weak A2 marks. Therefore some students progress to university with a very weak understanding of second year topics.

After each stage of the research (2008, 2009, 2010) I showed my work to my line manager (Head of Learning and Standards), who was particularly interested in how I used data to drive improvement. I also asked another Curriculum Leader for Science and Mathematics (from another Sixth Form College) if he would evaluate my final report, as he has over twenty five years of teaching experience and also works for AQA as a moderator of practical work.

For the external evaluation, I sent my work to the Head of Education (pre-19) at the Institute of Physics. Although he expressed considerable interest in my work, his written feedback was rather brief. Both evaluations can be found within the portfolio, after the main report into Student Performance in A level Physics Modular Examinations.

5.5 To what extent does subject choice depend upon wider social, cultural and economic factors?

This key research question was explored in Sections 7, 8, 9 and 10 of the portfolio, which developed as I became increasingly more concerned with the factors outside of the classroom that influence choice of subjects at A level and degree level study. Throughout my career, I have worked hard to inspire young people to study physics, yet I am profoundly aware that teachers are only one factor in a wide range of other influential factors.

According to the 'Set for Success Report' (Robert's 2002), the four factors that affect student choice are:

1) Teachers
2) Educational environment
3) Subject curriculum
4) Parents and the wider aspects of society

I would argue that this fourth factor is substantially larger than all of the other three factors, as it includes the social, cultural and economic factors that lie in the key research question. Parents can directly influence the type of educational establishment, which then has an indirect impact upon peers, the ethos of the establishment and choice of subjects.

Parents and home background play a very important part in shaping the decisions made by young people, which I investigated within Section 7 of the portfolio. My findings corroborated the work by Brooks (2003) in that all of the A level physics students (within the study) attended the FEC as it was the local provider of education. Whilst there were only two girls involved in this study, both said that their parents wanted them to be ‘happy’ or ‘comfortable’, and allowed them free choice in where to study. Some of the boys’ parents asked about the examination results, but on the whole, allowed the students to make their own decision on where they studied. My findings also concurred with Reay et al. (1998) who discussed social class and choice of school, finding that working class families chose establishments based upon locality and friendships, whereas middle class parents were far more concerned with the educational policies of the school. Desforges found that parental involvement is strongly influenced by family social class (DfES, 2003, p.4), which was shown to be true to some extent. However, it must be stressed at this point that neither social class nor parental involvement showed any direct correlation with achievement.

The choice of academic establishment has a direct effect upon what subjects and qualifications are on offer. Within the city, the FEC is the main provider of post-compulsory education (apart from three faith schools). It therefore has a wider curriculum than a school sixth form, catering for a broader range of abilities, subjects and qualifications.

As I investigated the ethos of the FEC in more depth, I learned more about the invisible yet vast complex political framework that underpins post-compulsory education. Compared to schools, the Further Education sector appears to be flexible yet incredibly fragile, subject to ever-changing funding methodology, political objectives and driven by targets. As Coffield explains: ‘Post-16 learning is currently subjected to a series of pressures from policy initiatives, financial directives, institutional change strategies, qualifications and awarding bodies, the inspectorate, CPD, and student demands’ (Coffield, 2004 p.134). Hayes claims that further education is: ‘dominated by quixotic, fast moving, internally imposed and often, poorly rationalised decisions’ (Hayes et al. 2007, p.9).

Each FEC is operated as an independent business, with financial viability being the over-arching objective. This crucial factor explains why the salaries of teachers in further education colleges are less than teachers in schools. As FECs are financially driven, they depend upon the number (and retention) of students for survival. In order to attract and retain students, the college environment is made as appealing as possible for the students. This has led to a very relaxed atmosphere within the sixth form centres, which contrasts sharply with the more formal approach of schools (and school sixth forms). The main point here being that the environment has been deliberately created to fulfil an economic and political agenda. Within the literature review, I have discussed the political background of further education in more detail (Chapter 3, Section 3.3.2).

The study contained within Section 7 of the portfolio outlines how the number of BTEC students has increased over a four year period, which from an educational perspective is excellent as it enables a range of student abilities to benefit from appropriate courses. This is clearly underpinned by the government targets driven by the political agenda at the time. The Labour manifesto 2005 (*Britain: Forwards not Back*) proposed that all young people up to the age of 19 should be in learning (Labour Party, 2005, P.39). It also proposed that Further Education should have dedicated centres for 16 to 19 year olds, which clearly has been the rationale for the establishment of the sixth form centres within the college.

JCQ (Joint Council for Qualifications) provides information on the proportion of A level candidates from different types of institution. Using the information from a range of educational establishments, I combined the data into three main sectors which are presented in Table 2 below, with the order of subjects being in the proportion of candidates from the FE/6th Form sector. Table 2 (page 181) shows the differences in the popularity of subjects between the different types of institutions. The main point to make from this table is that there is a less than average proportion of candidates from the FE/6th Form sector who pursue science and mathematics at A level, whilst at the same time, a greater than average (for that sector) proportion of candidates who pursue science and mathematics from the independent/selective sector.

TABLE 5.2

Proportion of A level Candidates from Different Educational Establishments

Subject	**Comprehensive/ Academy/ Secondary modern %**	**FE/6th Form %**	**Independent (Maintained/ Selective) %**
LAW	32.0	64.8	1.0 (2.2)
SOCIOLOGY	51.8	42.4	1.3 (4.5)
MEDIA/TV	52.6	41.6	2.5 (3.9)
PSYCHOLOGY	51.1	36.8	6.1 (5.9)
ALL A levels	47.7	29.8	13.4 (9.1)
MATHEMATICS	45.5	26.2	18.1 (10.9)
BIOLOGY	47.7	24.9	14.8 (12.6)
CHEMISTRY	44.9	24.9	17.9 (12.3)
PHYSICS	47.9	21.3	19.1 (12.2)

(JCQ, 2011)

Referring back to Roberts' four factors in the Set for Success Report, parents do have a large influence upon subject choice at A level, whether directly, or indirectly through choice of institution. Furthermore, choice of institution then places the student within the sphere of influence of a particular peer group. Hargreaves (1967) conducted a study into a secondary modern school and found that despite teachers blaming family background for the attitudes of the pupils, the influence of peers was far more important. Whilst there are many differences between this study and my own investigations, it can be extrapolated to my studies to explain that the type of students who attend a FEC may be different to those who attend faith or independent schools and each will then lead to different peer influences. Hargreaves (1972) discusses the formative influence of parents and friends, which can create attitudes towards education, as well as life expectations and aspirations.

Section 8 within the portfolio contains a study into the UCAS applications made by students from the FEC. In 2005, there were 449 applications to UCAS, of which 241 were from A level students (53%).By 2011, there were 817 applications, of which 245 were from A level students (30%). Whilst the number of A level students has remained the same, the increase in applications from vocational and non-traditional courses have increased significantly. When evaluating the applications from both A level and vocational students, the most popular degree courses lie in the fields of computing and business, which does tend to mirror the opportunities within this geographical area. When evaluating the applications from A level students only, social sciences emerge as the most popular subject group.

The proportion of students who apply for universities out of this area is very small. In 2011, 87.1% of all applicants from the FEC selected a local university, with 44.8% of all students selecting the university within this city. The fact that students from the college appear to be reluctant to move away from home was an issue that I was aware of, but prior to studying for the Professional Doctorate, I had not appreciated the wide range of academic studies into this particular problem. This issue is not confined to the north east of England, nor to this country, as a paper by Gos into ‘Overcoming social class markers: Preparing working class students for college’ identified the same problem in the USA, where working class families lived in the same locations for generations' (Gos, 1995, p.31). He claimed that middle class students were prepared to travel for employment or education, whereas for working class students, their family and local community were more important.

Reay et al. (2001) was particularly concerned with choice of higher education establishment: 'While more working class and minority students are entering university, for the most part, they are entering different universities to their middle class counterparts' (Reay et al., 2001, p. 858). They claim that 'less affluent' students relied upon part time employment to supplement their studies and discuss the fact that 'working class students appeared to be subject to emotional as well as material constraints on their choices' (Reay et al. p.863). The paper claims there may be psychological reasons why strong students do not apply to more prestigious universities with quotations from students in their research such as 'What's a person like me going to do at a place like that?' (Reay et al. p.864)

Evans claimed that working class girls often selected the local university, and this was true of the two girls in the study (Section 7), who had no interest whatsoever in moving away from home. Evans states that working class girls are affected by: 'family based altruism and a commitment to the maintenance of family ties and obligations' (Evans, 2009, p.342). When further analysing the UCAS destinations of A level physics students over a ten year period, there is only one girl who has moved out of the area for her degree (middle class) and she was selected for the case study in the portfolio.

As a widening participation college, where the majority of students are working class, moving away from home presents problems which are not constricted to financial worries but incorporates wider issues such as identity and family responsibilities. It is therefore understandable that the only students who have proceeded to study physics at university in the past ten years have been from middle class families. This also supports my belief that the reason that many students do not take up the study of physics at university is due to the lack of availability of realistic physics degree courses within this region.

Within Section 7 of the portfolio, I discuss the importance of role models. Throughout my career, I have always believed it important to give students the opportunity to meet real professional scientists, particularly in a working environment. I had not realised that in doing so, I was using the principle of role models as an educational tool. I used to find it curious that at the end of any talk, when a visiting speaker would ask if there were any questions, my students would invariably get onto the personal questions. Some speakers have not been comfortable with this and would rather adhere to serious, academic questions, but for students at the FEC, being able to empathise with this person and project an image of themselves working in a particular career is vital. As Cruess explains, we often learn through 'unscripted, unplanned and highly interpersonal forms of teaching and learning' (Cruess, 2008, p.719).

The role of the media is an important influence on the decisions made by young people. Very few students at the FEC will have a scientist in the family, so some of their concepts are shaped by the visual representations of the media. Kitzinger states the media sometimes presents women in SET in a way that is: ‘socially incompetent, victimised and somehow de-feminised’ (Kitziniger, 2008, p.16). The research suggested that it would be useful to show more female science presenters as well as more good quality science programmes on television.

A recent ‘blockbuster’ style movie *Contagion* (2011) has been praised by American academics as raising the profile of science in a very positive manner. Jonathan Moreno, a professor from the University of Pennsylvania claims ‘The movie treats science and government with respect’ and shows that the film ‘reminds us of the better angels of our nature. Sometimes they are the ones in the white lab coats.’ (Science Progress Website, 2011).

The recent increase in the number of AS physics students at the FEC is partially due to the influence of the media, with Brian Cox often quoted as a major source of inspiration (for boys as well as girls). As Cox was a member of a pop group prior to his career in science, and participates in television panel games, this increases his popularity and demonstrates to young people that you do not have to be an overly serious person to study a serious subject. Brian Cox is a person that young people can respect and admire for both professional as well as personal qualities, who contradicts the stereotypical image of a scientist identified by Mead and Metraux (1957) and Fraying (2005).

To return to the key research question, the influence of the media and the importance of strong role models can be regarded as wider cultural influences, and my studies show that this can be a very important factor in the choice of A levels or university course. The next section will consider the economic factors that shape the decisions made by young people.

Whilst the purpose of education is not solely for future employment, there are more people with level 4 qualifications (graduate level) in the region than meet the demand for employment (The North East Skills Priorities Statement 2010/11, p.8). Within Section 8 of the portfolio, I found that social science degrees were the most popular degree courses for A level students at the FEC, however there is not an employment need for social scientists within this area. The high unemployment rate for graduates in the region could be interlinked with the reluctance of young people to move geographical area, for those students who would not consider moving away for a university course may find it just as difficult to move away from home for employment. Considering that this is a predominantly working class area, with many of the students from the FEC being the first generation from their families to go to university, I would have expected a greater match between choice of degree courses and employment opportunities within the region.

As a science teacher, I constantly inform my students that the study of science will lead to excellent employment opportunities. After conducting the study in Section 8, and finding high levels of graduate unemployment in this region, I wanted to determine whether science degrees would lead to careers within this area, or whether young people would have to move away from home to develop careers in science professions. Section 9 of the portfolio started as an investigation into science-related careers, with a particular focus upon this locality.

Whilst working with the Connexions Service, I learned more about their internal structure and how careers officers have faced considerable organisational changes over the past ten years (again, underpinned by political frameworks). At the time of producing this report, there was a lot of political pressure to address the NEET problem (Not in Education, Employment or Training). However recent meetings have indicated there will be further changes in the priorities of this organisation over the next few years.

I was surprised to learn that the Connexions Service does not interact with university careers teams, and that university teams only help graduates from their particular university. The Connexions team could not provide the graduate information that I required, and the university Careers Department provided no help whatsoever. My requests for information about graduate employment from the most local university, where 45% of our students choose to study, were ignored. I am convinced that hard data on the employment of graduates from particular subject disciplines, from the most local university, would be of enormous benefit to our students.

Within Section 9, I considered the employment opportunities for non-graduates in science related careers, and at the time of the report, there were only three vacancies in the whole of the Tyne & Wear region. For young people who wanted to leave school with only GCSEs, the best route to a structured career (connected in some way with science) was with the Merchant Navy. It was clear that a young person could not realistically consider science related careers without degree level study.

With regards to graduate positions, the Prospects website and handbooks reveal that there are a wide range of opportunities for physics graduates, as well as those from other science, mathematics or engineering subjects. The only problem is that there are very few positions within this locality so young people must be geographically mobile in order to work throughout the UK. When considering opportunities which are specifically for physics graduates, it emerged that many employers value the transferable skills developed with this subject at degree level. There were opportunities for physics graduates in business, finance, engineering and computing.

The North East Skills Priorities Statement 2011/2012 (2010) states that there are more people with graduate level education than meets the employment needs within this region:

> The North East is characterised by a low demand for higher level skills. A higher proportion of the North East workforce is qualified to Level 4 than the occupational structure requires. Consequently, the lack of opportunity in the region discourages young people from progressing to higher level skills, existing skills are under-utilised and it is difficult to attract highly skilled individuals to the region.
>
> (North East Skills Priorities Statement, 2010, p.8)

The document ends on a more positive note by considering employment trends for the future. According to the North East Skills Priorities Statement (2011/12), there is hope that current developments in the region (North East of England) will lead to four prosperous branches of scientific industries within the next ten years. These are:

1) Biotechnology – The National Industrial Biotechnology Facility in Tees Valley is expected to generate over £11bn by 2025. This will require graduate and postdoctoral level skills in chemistry, biology and engineering.

2) Plastic Electronics: The Plastics Electronics Prototyping Centre (PETEC) is based at NETPark, County Durham. This will require specialists in electronics and electronic engineering.

3) Offshore Wind: The National Renewable Energy Centre (NaREC) in Blyth is currently the world's largest offshore wind blade test facility. It is estimated that further developments will create up to 16,000 new jobs in the North East, including a predicted 7,000 electrical and mechanical engineers, with further jobs in manufacture, construction, installation and maintenance.

4) Ultra-Low Carbon Vehicles: The North East is one of the first national Low Carbon Economic Areas. The world's first affordable mass produced zero emission cars will be manufactured by Nissan (Sunderland). The skills required will be electrical engineering competencies at technician level.

(North East Skills Priorities Statement 2011/12, 2010, p.12)

Section 10 of the portfolio considered various support organisations that are available to support women in scientific careers. Currently, many educational establishments are working towards Athena Swan recognition, which is for offering equal opportunities for women in the workplace and recognising the under-representation of women in some fields. It was also noted that the lack of formal career structure for academics posed a problem for all post-doctoral students, irrespective of gender.

Returning to the key research question, of whether economic factors influence student choice of A level, I would argue that it does not appear to do so at present. From the study in Section 8 of the portfolio, I am not convinced that students from the FEC are given sufficient information in order to select appropriate degree courses. It appears that students are selecting their favourite subject and hoping that graduate education will automatically lead to greater employment prospects. From the Skills Statement, there are more graduates within the region than meet the demand for this level of qualification. Whilst there is hope that in the near future, there will be greater employment within scientific careers, at present, science graduates need to be geographically mobile in order to develop their careers.

There are a wide variety of employment possibilities across the UK for graduates with numerical, scientific or engineering skills. This has led to some strong recommendations in the next chapter for greater communication between university careers departments, the Connexions Service and employers within the region to provide greater advice for young people, including possible financial attractions to ensure that students study subjects relating to employment and the economic growth of the area. It is also important that we encourage young people to be more geographically mobile and education in its wider sense is about opening opportunities rather than closing them.

5.6 Summary

The first objective of this study was to consider the current levels of participation with physics in post-compulsory education and why it is important to increase the number of young people who study physics at both A level and university. The second objective was to consider different strategies for engaging students with the study of physics in post-compulsory education and to determine the impact that teachers can make on this engagement.

Each of the ten sections contained within the portfolio has explored a different strand of these issues. Each section has been shared with colleagues and managers within the FEC, as well as professionals from external agencies. There are further areas that could be explored in order to extend this study. One of the main issues that I believe should be investigated further is that of social class and educational opportunities in the twenty first century. Throughout this entire study, which has included the issue of gender and equality, the separate issue of social class and equality has been touched upon several times. A paper by Reay et al. states that there are 'various forms of social closure which operate to reproduce existing inequalities within the higher education sector' (Reay, 2001, p.855). I would argue that this extends into all other areas of education. Social class directly influences the choice of educational establishment (whether school, sixth form or university), the subjects available in these establishments, the ethos of the establishment, aspirations of peers, aspirations or expectations of parents, as well as having role models of professional status either within the family or close friends. Whilst social class was not an intended feature of this study, it is silently threaded throughout the body of this work.

Having conducted this study in order to reflect upon my teaching and encourage more young people to study physics, I have been alerted to the vast range of political structures which frame the educational process. For example, many of the decisions made at the large FEC are to make the organisation financially viable and to increase performance in league tables. At the end of each academic year, individual teachers are held accountable for their performance with the results for each class being intensely analysed to determine the retention, the pass rates, the success rates (pass rate x achievement), the proportion of high grades and the number of students who achieved their target grade. This places incredible pressure on teachers and results in pressure to train students for the examination process rather than to foster a love for learning and a thirst for knowledge. This was a particular dilemma with Section 4 in the portfolio, where we had to evaluate what was most important for the student, interest and engagement with the topic or examination success.

Whilst the original study was concerned with a large FEC based in the north east of England, this by no means confines the study to this region. Through my contacts with the Institute of Physics (Consultants for Stimulating Physics and the Editor of Physics Education), I have been informed that many issues raised apply to all over the United Kingdom. For example, the shortage of specialist physics teachers, the shortage of female physics teachers, the fact that students apply to local universities and often change choice of degree in order to remain at home (the 'physics desert' problem), the issue of students' written communication (the Examiner's Report, 2008, indicated that this was a national problem) and the need for specialist careers advice are all issues that apply to the whole of the country and are not specific to this geographical region.

Chapter 6 Recommendations and Conclusions

Having discussed the findings from each of the sections contained within the portfolio in Chapter 5 of this report, it is now important to produce recommendations that can have an impact upon the profession, as well as draw the study towards a conclusion. The recommendations can be divided into those for practising classroom teachers (6.1), educational establishments (6.2) and national organisations (6.3). I will then conclude the report with a discussion of the contribution of this study, including suggestions for further research (6.4) and reflections upon my personal learning journey (6.5)

The aim of this study was to investigate the participation and engagement of young people with the study of physics in post-compulsory education, with the specific objectives of:

1) To explore the current levels of participation in post-compulsory physics education and consider why it is important to increase the number of young people who study physics.

2) To look at different strategies for engaging students with the study of physics in post-compulsory education and determine the impact that teachers can make on this engagement.

Within the portfolio, Sections 1 and 2 address the first objective, whereas all of the other sections were related to the second objective (as shown in Chart 1.1 on page 9). At the end of each of the following recommendations, there is an indication of how each of these suggestions has emerged from the sections contained within the portfolio. After section 6.3, all of the recommendations have been summarised in Table 6.2 (page 209).

6.1 Recommendations for physics teachers

1) The enthusiasm of a teacher is the most important quality valued by young people. This has been stated in government reports, academic literature and found directly from the focus group conducted in Section 1 of the portfolio. The Set for Success Report (2002) highlighted that it is the enthusiasm of the teacher that captures the pupil's interest and motivates them to study (Section 2.35). In Chapter 3 of this report, Section 3.2.2 discusses the importance of good teaching in physics, particularly as Murphy and Whitelegg found that there was some evidence that science teachers show less friendliness or understanding towards students than teachers of other subjects. (Murphy and Whitelegg, 2006, p.24). In Section 3.4.3, the vital importance of emotion in teaching is discussed with Hargreaves suggesting that teaching is about establishing bonds, forming relationships with students, inspiring excitement and wonder and ensuring all students are included (Hargreaves, 1997, p.ix).

The importance of enthusiasm for both the subject and teaching young people is further supported by Muijs and Reynolds (2005), Kyriacou, (2009) and Cooper (2011). Therefore teachers must never lose sight of this single most important factor. The enthusiasm and commitment of a teacher inside the classroom is an investment for the amount of effort that students may put into their studies outside of the classroom. (Sections 1, 2 and 3)

2) It is important to engage students with topics that they find interesting and relevant to their lives. For many students, astronomy is a popular topic, shown in both the literature review (Osborne and Collins, 2001) and with the case studies.

Research outlined in the literature review suggests that girls may find the more humanistic aspects of science appealing. This is supported by Stewart (1998), Hoffmann (2002), and Murphy and Whitelegg (2006). The UCAS data shows that forensic and archaeological sciences have a high proportion of female students (66%), so elements of these subjects could be developed within schools or colleges to engage young people with physics. Hollins suggests in ‘Girls in the Physics Classroom’ that surveys can be a starting point for exploring the interests and motivations for (all) students (2006).

Finding topics or examples that can engage students is useful, but from my study into examination performance there was no evidence that ‘interest’ correlates to ‘achievement.’ (Sections 2, 4, 5 and 10)

3) Continually reflect upon teaching and learning within the classroom. Design lessons that will interest and inspire all students. Use a variety of resources in order to develop a range of skills with students. Murphy and Whitelegg suggest that physics teachers use a variety of methods such as laboratory work, group and class discussions, problem solving, project based activities, as well as creative writing (Murphy and Whitelegg, 2006, p.28).

Whilst many students who choose to study physics at A level prefer numerical problems and independent learning, the importance of developing strong written and verbal communication must not be underestimated. The work of Bernstein (1971, 2000) was particularly relevant for this study, as students at the FEC speak and write in ‘restricted codes’. Gos suggests that teachers can help working class students develop middle class literacy by ensuring that within lessons, there is ample practice within written assignments and class discussions. He states: ’Working class students will resist this initially, but with practice, it will become easier’ (Gos, 1995, p.33). I strongly believe in the importance of good communication skills, both written and verbal, which not only help students to achieve better academic results at A level, but will develop social confidence to integrate into the more challenging world of Higher Education. (Sections 3 and 4)

4) During lessons, outline the need to work collaboratively and on an international level, using the Large Hadron Collider as a contemporary example. Ensure that students realise that it will be necessary to work at different locations around the country in order to develop a career in science. Talk to students about this so that they are not in fear of geographical relocation. Try to give examples in lessons of different companies and explain where they are located. (Sections 8, 9 and 10)

5) Make the laboratory or teaching room as pleasant as possible. Use posters, examples of students’ work and visual aids to make the learning environment a pleasant and inclusive place to work. Showing that you value students’ work can build up empathy with students and create an atmosphere of mutual respect. As Cooper states, mutual respect can lead to

greater engagement and shared enthusiasm for learning (Cooper, 2011, p121).

Some of the misconceptions about science, perhaps as a result of the external influences upon young people, can be addressed within the teaching environment. For example, develop a careers notice board within the laboratory, providing information about careers in science at every level of education. You will find that the local Connexions Office will be more than happy to help. Use the Prospects website or handbook, or the UNISTATS site for graduate careers information. I found that my display of former students who had progressed to careers in science was of interest to students, as well as television celebrities who had physics degrees. (Sections 1, 3, 8 and 9)

6) Develop links with local employers to determine what opportunities are available within a particular region. Encourage visits to scientific companies so that students can gain first-hand experience of what it is like to work in the science industry. The importance of role models must not be under-estimated as it is crucial that students can visualise what scientists do and how they live their lives.

Work with STEMNET to take advantage of the wide range of extracurricular support opportunities available. The Science Ambassador scheme can provide role models who can come along and talk to students.

Develop links with local universities. If physics is not offered, then liaise with the engineering departments. Most university departments are more than happy to show their facilities and research to prospective students. (Sections 2, 7, 8, 9 and 10)

7) If the opportunity arises, participate in Action Research Projects, whether subject based or inter-disciplinary. This often provides a fresh perspective for sharing different teaching strategies, developing new resources and above all, support. When participating in the Action Research Project within this study, I found the other teachers and the organisers were extremely helpful, supportive and above all, inspirational. As McNiff suggests, good teachers are learning all the time and she recommends that teachers ‘make an unqualified commitment of self to the education of self, in the interests of the education of others’ (McNiff, 1993, p.21). (Sections 3 and 5)

8) Use modular examination results for analysing trends in student performance in different modules. This data may reveal topics that students find difficult and help to modify teaching methods for future classes. My study into exam performance identified an optional module which yielded particularly weak results.

Bear in mind that when students are taking a modular course, boys tend to take advantage of the opportunity to re-sit examinations more than girls. From the academic literature (McClune, 2001) and evidence from my study, girls are less likely to re-sit than boys. (Section 4)

9) Contact the local Science Learning Centre to find out about events in your area. Working with external agencies provides valuable support, particularly if physics teachers are working in schools or colleges without the day to day support of other physics teachers. In some of our partner schools, there is only one physics teacher in a science department, which can be quite an isolated situation. Therefore it is important to make use of external agencies in order to maintain contact, support and above all, encouragement from other physics teachers.

The Institute of Physics provides valuable support for teachers, with the 'Talk Physics' site and a vast range of resources available for lessons. Their Stimulating Physics co-ordinators can provide support and inspiration for teachers. (Sections 3 and 5)

6.2 Recommendations for educational establishments

1) Educational establishments with a high turnover of teachers, whether science or any other academic area, must seriously consider the potential problems that are driving teachers to leave the organisation. Whilst the 'Golden Hello' scheme was introduced to recruit new teachers in shortage subjects, there is still a serious problem with the retention of physics teachers. Schools should try to increase the number of physics specialists and encourage applications from female physics teachers. (Section 1)

2) There are several open evenings for parents of prospective students to attend the FEC and find out more about the educational opportunities on offer. This could be extended so that parents are provided with a wider range

of information regarding employment and higher education that can follow by studying the various A level and vocational courses. Greater liaison between local universities and sixth forms, with information sessions for parents would be useful, particularly for those families who have little experience of higher education. Sixth forms could host evenings aimed for students and their parents where they can meet representatives from a range of professions. (Sections 1, 2, 7, 8 and 9)

3) Within tutorial sessions, encourage young people to consider working in different places. Bring in role models who have worked in different parts of the world. Encourage students to adopt a more adventurous approach towards their future career and consider living in different places. Show that a greater understanding of living and working with other cultures can contribute towards a more fulfilling life than remaining in the same locality all of one's life. (Sections 8 and 9)

6.3 Recommendations for national organisations

1) There must be an increase in the number of specialist physics teachers within schools, so that physics is not taught reluctantly by other science teachers within a department. As mentioned in the previous section, there are some local schools where there is only one physics teacher in a science department.

The Institute of Physics has recently launched a new initiative to encourage physics graduates to train to be teachers, offering 100 sponsorships of up to £20,000 to cover the costs of training. As this scheme is selective, however, and will depend upon the class of degree awarded, it has already created some concerns with physics graduates that class of degree is not always the best indicator of who will make the best teacher. The initiative will, however, raise the profile of physics teaching and hopefully attract well-qualified graduates into the teaching profession. The retention of well qualified physicists within teaching is debatable. (IOP, October 2011).

Whilst it may sound very patronising, it is imperative that Teacher Training courses for physicists address the need for empathy in teaching. The students in the focus group raised the fact that some of their physics teachers were lacking in interpersonal skills. This has also been identified by the literature (Murphy and Whitelegg, 2006). (Section 1)

2) There must be an increase in the number of female physics teachers, not only to provide role models but to bring different inter-personal skills to the physics team. It emerged from the focus group that some young people had never been taught physics by a female teacher. (Section 1)

3) The availability of physics degree courses must be addressed. Within the whole of the north east of England, there is only one university where physics is offered as an undergraduate degree course and this university has exceptionally high entry requirements. If students from the FEC cannot achieve these high grades, they choose other subjects to study rather than move away from home. A spokesperson for the Institute of Physics has stated that this problem is not confined to the north east of England, but applies to other areas of the UK. Universities claim that physics degrees are

expensive to run and that they need sufficient students to be financially viable. There must be an investment from government towards STEM education at graduate level, whether greater funding for universities or contribution towards tuition fees for students. (Section 2)

4) Examining Boards must consider the content of the GCSE specifications. The data presented in Section 1 of the portfolio shows an increase in the number of young people who are studying physics at GCSE, with a healthy proportion of girls who study this subject. There is clearly something wrong with physics at GCSE level as this does not appear to be encouraging young people to take this subject forward to A level.

Some of the points raised by the Heads of Science from our partner schools mention that the GCSE physics specification is ‘rather dry’ (although caution must be taken when the subject content is reviewed by a non-specialist teacher). The topic of space has great appeal to young people, so this could be further developed within the GCSE course. (Sections 1, 2, 5 and 10)

5) Examining Boards could analyse data from the A level physics examinations (in a similar study to that which I conducted with data from the FEC) to determine whether there are any topics that show any form of gender differences in examination performance. It would be useful to have more quantitative evidence to support the development of teaching and learning strategies within the classroom. (Section 4)

6) There must be a vast improvement in the careers service for young people, whether from Connexions or internally appointed advisors, who can provide information on potential skill shortages and employment opportunities. At present, the agenda of the Connexions Service is too wide and has a focus upon the lower end of the academic spectrum (NEETS). With regards to graduate careers and opportunities within this area, the Connexions team could only point me in the direction of the Prospects websites and handbooks, but had no first hand information on the employment of graduates within this particular area (local) or region (north east of England).

As young people within this area are reluctant to move away from home, careers advisors must ensure they are fully aware of the employment trends in this particular region. Make sure that young people are provided with sufficient information about STEM opportunities. It is also important that information is not aimed solely at the student, but provided for parents as well.

The University Careers Teams and Connexions must provide a more co-operative and coherent service to ensure that information is passed between organisations. It would be useful for schools, university career departments, careers advisers from Connexions and local employers to work together to identify skills required in the near and longer term future. (Sections 1, 2, 8 and 9)

7) Most universities are now providing packs for parents on their websites, clearly recognising the importance of engaging parents with the

educational process. The quality of this information varies between different institutions. It is crucial that parents understand the nature of higher education and have as much information as possible in order to allow their children to make good decisions. Particularly now that tuition fees are being increased, it will be essential to provide information for parents. (Sections 1, 2, 8 and 9)

8) Employers could develop more ‘Earn as you Learn’ schemes to help alleviate the burden of financial worry created by the higher tuition fees. It is vital that teachers, universities and employers recognise the potential of intelligent working class students, many of whom are deterred from applying to university by the costs of education. Bursaries could be made available to working class students who choose to study physics or other shortage subjects. (Sections 8 and 9)

9) Representations of science in the media – more quality television programmes, featuring more scientists rather than simply ‘presenters’. Develop television programmes to show how science can help solve the world’s problems and portray the more humanistic aspects of science. (Section 7)

10) Greater support for women in the workplace. Schemes such as Athena Swan have helped organisations to be more aware of the problems that women face at work. Employers to show more consideration of the

individual needs of employers and, whenever possible, develop flexible modes of working. (Section 10)

11) Whilst this is the final recommendation, I believe that it is very important for the government to address as a matter of urgency. There must be a thorough investigation into post–compulsory education within the UK, particularly the provision within further education colleges.

At present, pupils from state schools within this city have no option (other than a faith or independent school) but to attend the FEC. Choice is only for those who can afford it, not for working class pupils. At the FEC, which is typical of all colleges and not exceptional, teachers have less favourable salaries and conditions than school teachers, leading to an unstable and transient work force.

The Set for Success Report (Robert's 2002) suggested that teachers of shortage subjects could be paid higher salaries, yet this has never been implemented with the FEC (Section 0.6). 'The Science and Innovation Investment Framework (2004 to 2014) Report' suggested that Advanced Skills Teachers should be paid up to £40,000 (Section 6.21), which again, has never been mentioned in the world of further education. The Investment Framework Report also identified that there were problems attracting and retaining teachers in the further education sector, but largely skirted over the political issues with statements such as: 'There is a lack of robust national data on the recruitment and retention of SET post-16 teachers' (Section 6.38).

Many newly qualified teachers are delighted at the prospect of working in a college, as teaching A levels to older pupils can be far more intellectually satisfying than teaching in a school. Very soon, however, teachers realise that working in a school can offer greater financial rewards, career structure and job security. At present, new teachers within the science department at the FEC have been appointed onto Band B contracts which have a ceiling at £29,000. As this is well below the top of the scale for main grade school teachers,[3] it is creating a situation where science teachers (as well as those from other disciplines) at the FEC feel under-valued. Over the past few years, the FEC has had a particularly high turnover of science and mathematics teachers, which has not only been due to the poorer salaries, but due to the more demanding terms and conditions than working in a school.

The situation is even worse for the tutorial team, where new tutors are now appointed to a maximum salary of £24,000. In many cases, the A level tutors are agency staff who are paid by the hour and therefore not available to deal with the vast range of problems that have been highlighted in chapter 2 of this report. Ten years ago, the FEC took great pride in creating an excellent support system for our students, which mirrored the highest achieving sixth form college in the UK. Whilst Greenhead College has maintained its first class pastoral system, the FEC identified tutorial as an area where significant savings could be made. From my five years within the (former) pastoral team, as discussed in Chapter 2, I am fully aware of the

[3] The top of the main grade pay scale for a teacher within this area is currently £36,756 (NUT, 2011).

very important role that tutors play in supporting our students through their studies at the college.

It appears that the government is mainly interested in compulsory education, with Further Education being wilfully neglected. The problems facing teachers working in further education was highlighted by Robson in 1998, in the paper ‘A Profession in Crisis’. ‘It is time to attach a proper value to the FE teacher’s professional role, *as teacher*, and to address the future of a sector which has yet to receive the kind of support and attention it deserves’ (Robson, 1998, p.604). Williams, in *The Lecturer’s Guide to Further Education* claims that FE is the middle child, or the Cinderella of education (Hayes et al. 2007). Clearly, a review of the salaries, terms and conditions for those teachers who work in the FE sector is crucial. (Section 1 of the portfolio)

Table 6.1
Summary of Recommendations

For physics teachers	1) Demonstrate an enthusiasm for physics and a passion for teaching.
	2) Engage students with topics that they find interesting and relevant to their lives. • Space has been found to hold wonder and enthusiasm for most young people. • Girls may be interested in the humanistic elements of physics and applications towards society.
	3) Use a variety of teaching methods and learning activities within the classroom. • Develop good written communication skills, which will not only help in examinations but prepare students for university. • Whilst physics students often prefer calculations, ensure that students are stretched beyond their comfort zones.
	4) Develop collaborative working – explain this is the way that scientists work today. Encourage students to consider working in other places or abroad.
	5) Make the laboratory a pleasant and stimulating place to learn. • Value students work and place it on the walls. • Make a careers notice board • Pin up articles where physics has featured in the media • Use the laboratory walls for overcoming any misconceptions or stereotypes
	6) Develop links with employers, universities and STEMNET. • Meet role models so that young people can identify with scientists. • Arrange visits to dispel misconceptions
	7) Participate in Action Research Projects
	8) Use modular examination results for analysing trends in student performance in different modules.
	9) Work with the regional Science Learning Centre. Make use of external agencies in order to maintain contact, support and encouragement from other physics teachers, for example, IOP 'Talk Physics' community.

For educational establishments	1) Give consideration to the recruitment and retention of specialist physics teachers, and try to encourage applications from female physics teachers
	2) Invite parents to information evenings about Higher Education and employment. Most careers events are for young people, yet parental support is paramount.
	3) Encourage young people to develop a more open minded approach to working in different places. There are far more employment opportunities if young people are prepared to travel.
For national organisations	1) Increase the number of specialist physics teachers within schools. • Try to reduce the teaching of physics by non-specialists. • Teacher Training courses for physicists to give greater consideration to personal skills such as empathy and relationships with students.
	2) Increase the number of female physics teachers, not only to provide role models but to bring different inter-personal skills to the physics team.
	3) The availability of physics degree courses must be addressed. • There must be an investment from government towards STEM education at graduate level, whether greater funding for universities or contribution towards tuition fees for students. • If more physics degree courses were available locally, there would be an increase in the number of working class students who studied physics.
	4) Whilst there are healthy numbers of students who choose to study GCSE physics, this is not translating into strong numbers for A level. Examination Boards must consider the GCSE specification to determine if the content is causing this problem.
	5) Examining Boards to analyse data from the A level physics examinations to determine possible gender differences in examination performance.
	6) There must be a vast improvement in the provision of careers information for young people. • As young people within this area are reluctant to move away from home, careers advisors must ensure that young people are aware of the

	employment trends in this particular region. • It is also important that careers information is not aimed solely at the student, but provided for parents as well. • The University Careers Teams and Connexions must provide more a more co-operative and coherent service to ensure that information is passed between organisations.
	7) Universities to improve information packs for parents, particularly now that tuition fees are set to increase.
	8) Employers could develop more 'Earn as you Learn' schemes to help alleviate the burden of financial worry created by the higher tuition fees.
	9) Encourage more quality television programmes about science. • Feature real scientists rather than simply 'presenters'. • Develop television programmes that show how science can solve world problems and portray the more humanistic aspect of science.
	10) Greater support for women in the workplace, particularly as sciences are traditionally male dominated professions. • Employers to show more consideration of the individual needs of employers and whenever possible, develop flexible modes of working.
	11) There must be a thorough investigation into post–compulsory education within the UK, particularly the provision within further education colleges. • There must be a national investigation into salaries, terms and conditions for A level teachers in schools and colleges, and account for why there are differences. • Why should A level teachers in colleges be paid far less than GCSE teachers in schools? This one factor is driving many talented teachers out of the sector as well as de-motivating current teachers.

6.4 The contribution of this study

The first objective of this study was to consider the current levels of participation in physics in post-compulsory education and why it is important to increase the number of young people who study physics at both A level and university. It was shown that whilst the numbers of candidates who study physics at GCSE has increased over the past ten years, with an increasing proportion of girls, the trends for A level and degree are not as healthy. It is important to attract more young people to study physics at A level in order to fill potential skills gaps in the future, with girls an important subset of this group.

The second objective was to consider different strategies for engaging students with the study of physics in post-compulsory education and to determine the impact that teachers can make on this engagement. Within the portfolio, a range of strategies have been studied, and whilst the teacher can be a significant influence upon a young person, there are a range of external factors which can also shape the decisions made by young people.

Each of the ten studies contained within the portfolio has explored different strands of the issues. Each study has been shared with colleagues and managers within the FEC, as well as professionals from external agencies. Through conducting this study, I have had the opportunity to work with a wide variety of professionals and engage with a range of external organisations, thereby strengthening links and building up a network of contacts.

The contribution of this study can be evaluated quantitatively in terms of the increase in the numbers of young people who are studying physics at the FEC, with a greater proportion of girls (see Table 6.2).

Table 6.2

The Number of Students Enrolled on AS Physics at the FEC

YEAR	Number of Girls	Number of Boys	Total Number of Students
2009/10	4 (9%)	42 (81%)	46
2010/11	10 (16%)	53 (84%)	63
2011/12	20 (25%)	80 (75%)	100

There has also been an increase in the number of students who are applying to study physics-related courses at university, such as engineering. Having been concerned with the apparent decrease in popularity of physics at the FEC since 2000, I believe that the framework of a professional doctorate programme has provided a support mechanism for driving improvement, for undertaking reflective practice and for taking more independent initiative.

The contribution of the study can also be evaluated qualitatively by considering the changes that I have made to my own practice within the classroom, as well as the training that I have provided for other teachers. I have conducted several training sessions within the FEC on the need to develop good written communication skills in science as well as the importance of sustained concentration. Both of these titles originated from my work for the doctorate, yet are generic themes that can applied to other disciplines. I have also made presentations at the Science Learning Centre on the Action Research Project and a presentation on Girls and Physics at Sunderland University (February 2011).

Throughout the duration of this study, I have been intrigued by the vast range of political structures that underpin education, which were previously outside the perimeters of my role. Having worked in further education for many years, I was aware that this type of educational institution experiences continuous change, whether new courses are starting or others closed, being dependent upon external funding sources. The doctorate programme has raised my awareness of the political, economic and sociological aspects of education.

The intense scrutiny of examination results and making individual teachers more accountable for their own performance puts incredible pressure on staff to train students for the examination process rather than foster a love for learning and a thirst for knowledge. This was a particular dilemma with Section 4 in the portfolio, where we had to weigh up what was most important for the student - interest and engagement with the topic or examination success. Despite a much greater focus upon Continuous Professional Development within the teaching profession, the actual heart of teaching has been seriously bypassed. There are training sessions on a variety of the ‘technical skills’ associated with teaching, but there has never been any thought given towards developing personal skills such as empathy.

As Cooper states: ‘Vast sums of money are spent on research projects into teaching strategies and curriculum, which are not the main issue in school improvement’ (Cooper, 2011, p.246). She suggests an improvement in staff-student ratios at all levels, with an increased focus upon the quality of relationships, which will then lead to more effective learning. Whilst this is generic for all teachers, it is absolutely crucial for science teachers.

Whilst the original study was concerned with a large FEC based in the north east of England, the issues raised are not confined to this geographical region. Through working with the Institute of Physics (Consultants for Stimulating Physics and the Editor of Physics Education), I have found that many issues related to physics apply all over the United Kingdom. For example, the shortage of specialist physics teachers, the shortage of female physics teachers, and the issue of students changing their choice of degree in order to remain at home (the physics desert problem).

I would anticipate that research conducted over the next five years will show that the social class issues relating to university choice will increase rather than decrease. At the time of producing this report, tuition fees for undergraduates are about to rise to around £9,000 per annum. It may be interesting to see if applications for the Open University, or other Distance Learning Courses, increase in popularity if working class students are deterred by these increased tuition fees. It is essential that research is conducted to determine what effect this will have upon working class students, particularly with the study of physics at university.

The issue of social class and physics is threaded throughout this study. It was found that independent schools have a greater proportion of pupils taking the more traditional subjects, such as sciences, mathematics and modern foreign languages, whereas within the further education sector, subjects such as psychology, media studies, law and sociology are more popular. Within Chapter 5 of this report, it was found that physics degree courses have a greater (than average for the sector) proportion of students from higher social class backgrounds.

Since working class students from the FEC are often unable to move away from home, and the only students who have progressed to study physics at university have been middle class, this local situation is contributing towards the current social class structure of physics. It is not difficult to envisage that a career in teaching may not appeal to students from higher social backgrounds, which will then create further shortages of physics teachers and lead to a far greater problem with physics education in the future. I predict that within ten years, many further education colleges will not be able to sustain physics as an A level subject although this subject will still remain popular in the independent sector, along with other traditional academic subjects such as modern foreign languages.

There are other issues that can be extended and applied to the whole country, and are not confined to this region. For example, the issue of students' written communication and the need for specialist careers advice are all issues that apply to the whole of the country and are not specific to this geographical region.

There are several areas that could be further explored in order to extend this study. Whilst the issue of gender imbalance in physics has been an integral component of this study, the separate issue of social class has emerged as an important strand that requires further investigation. In the words of Reay, there are: ‘various forms of social closure which operate to reproduce existing inequalities within the higher education sector’ (p.855). Social class directly influences the choice of educational establishment (whether school, sixth form or university), the subjects available in these establishments, the ethos of the establishment, aspirations of peers, aspirations or expectations of parents, as well as having role models of professional status either within the family or close friends.

Another area of research could be an investigation into A level physics examination performance, considering questions or topics where there are gender differences. This could lead to a greater understanding of how boys and girls perceive different topics and shape teaching and learning in the classroom.

6.5 Reflections upon my personal learning journey

When the prospect of studying for a professional doctorate was offered to all staff at the FEC, I was interested in pursuing this goal as I believed it would provide a stronger framework for investigating several of the issues that shaped my daily professional practice. Having already embraced many initiatives, I believed that the structure of the course would draw together many areas of interest and provide an overarching framework to my studies. I also found that by studying for a professional doctorate, it provided the legitimacy and confidence to ask far more searching questions and pursue lines of inquiry beyond normal access.

Whilst I realised the course would require a considerable investment of time, I perhaps had not realised the extent that this would shape my life, both personally as well as professionally. One of the first points to note is how it felt to be a student again, from the very start of the course such as joining the university library and conducting the literature review. Placing myself in the position of a student made me so much more aware of the difficulties one encounters, when enthusiasm turns to exasperation. The process of academic writing proved difficult, particularly as a mature student. Throughout the course, my students have been aware of my studies and they have been particularly enthusiastic and supportive, particularly when I have explained some of my findings with them.

Liaising with external organisations has created a network of contacts with whom I work with on a more regular basis, which not only benefits my students but has provided a great source of inspiration for myself. Whilst I received many comments and constructive criticisms over the duration of the programme, it was almost always helpful and improving. In fact, the only times that I felt disheartened were the times when I sent copies of my reports to particular managers and then never received any feedback whatsoever. Reading feedback on my own work has increased my awareness of how a student feels when receiving comments, which has indirectly led to creating new feedback sheets for student assignments.

The culmination of my efforts was most certainly when I was awarded the runner up position for WISE Advisor of the year (2011), receiving a framed certificate from the Princess Royal in London (October 2011). Having been nominated by my tutors at the university, I was very pleased and proud that my efforts to improve professional practice were recognised. After receiving the award, there were features about my work in the university magazine and the local newspaper. It was particularly pleasing to receive many emails of congratulations from former as well as current students from the FEC.

Concluding this report is particularly difficult as it is drawing to an end a personal as well as professional journey, where I have learned just as much about myself as about physics education. My journey over the past few years has involved the development of skills such as reading academic literature, academic writing, as well as synthesising, analysing and evaluating information. It has also included training other teachers and making presentations both inside and outside of the organisation. Above all, the journey has been made with a wide range of friends, who have been incredibly positive, enthusiastic and encouraging. Hopefully, my passion for teaching will continue and this will not be an end but a new beginning.

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