THE IMPACT OF THE STIMULATING PHYSICS PILOT ON STUDENT UPTAKE OF PHYSICS POST-16

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Abstract

Stimulating Physics, a HEFCE-funded initiative of the Institute of Physics (IOP) sought to increase the number of physics A level students by 30% over a five year period. In the pilot phase, between January 2007 and July 2009, schools received targeted support for subject-based professional development for non-specialist teachers of physics and pupil engagement activities.

This project presents a longitudinal study into the effectiveness of the pilot, examining key performance indicators and evaluating the efficacy of the professional development to determine whether there have been enduring changes in the attitudes, pedagogy and organisational structure in schools. Questionnaire and interview responses from pilot schools were augmented with secondary data from the National Pupil Database, permitting quantitative comparisons with control schools within the same local authority regions that had not participated in the pilot. At AS level there was a significantly greater increase in the proportion of Year 12 students opting for physics in pilot schools compared with control schools. The national pupil database shows an increase of 55.8% in the number of Year 13 A level entries in 2009/10 compared to 2005/06 exceeding the IOP's target. A more modest (33.5%) increase in participation in physics occurred in control schools in the same period which may be attributable to other factors including curriculum changes and popularisation by the media.

The most positive changes in the uptake of girls were seen where there had been targeted activities related to raising the profile of physics and careers. Departments demonstrating a sustained change in their working practices characteristically provided time within the school day for development opportunities for the whole department and had subject leaders that actively participated in the CPD. Students described novel teaching approaches in schools where physics specialists were in short supply, and highlighted the importance of having enthusiastic physics specialist teachers.

Contents

List of figures

List of tables

List of appendices

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This dissertation is dedicated to the memory of my father, James Alexander Harris, who nurtured my interest in maths and science from an early age.

Author's declaration

I hereby declare that I am the sole author of this thesis. Secondary data was obtained from the National Pupil Database. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

1 Introduction

This research project explored the impact of the Stimulating Physics pilot, an initiative designed by the Institute of Physics (IOP) to increase the number of students opting for A level physics and thereby supplying suitable qualified and motivated physics' undergraduate students. As a regional officer in the pilot I worked with schools in Leeds from January 2007 to July 2009 providing continuing professional development (CPD) for teachers. The main focus of this research was whether the pilot had achieved its aims of raising student uptake in physics, also of interest was if any enduring changes in practice had been embedded in the schools and the exploration of the mechanisms behind effective CPD.

Although I have a professional interest in the subject under scrutiny in this report, I have ensured that the research has been objective and primarily focussed on the quantitative aspect of measuring impact. Focus groups with students and teacher interviews helped to clarify whether the activities used in the pilot had become part of the everyday teaching and learning in the schools. It is hoped that the findings of this research can be used to inform future practice within the Stimulating Physics Network, an expanded version of the school-based strand of the pilot which covers nearly 300 schools in the UK.

1.1 Stimulating Physics

1.1.1 Development of the Stimulating Physics pilot

The Stimulating Physics pilot was developed by the Institute of Physics in response to the Higher Education Funding Council (HEFCE)'s report on Strategically Important and Vulnerable subjects in Higher Education (HEFCE, 2005). HEFCE reviewed data from 1999-2000 and 2003-2004 from the Higher Education Statistics Agency (HESA).

It was felt important to ascertain where misalignment in supply and demand might occur, and the report suggested that this "may be observed in:

- curriculum or assessment mismatch between school, college and higher education
- lack of clear information, advice and guidance about progression to HE at school or college level
- poor relationship or communication between employers and HE institutions, meaning that the curriculum is not delivering the national skills needs, or that research is not delivering what industry requires
- poor match between regional skills needs (for example, at the technician level) and regional HE supply
- the cultural and diplomatic need for particular subjects being insufficient incentive for students to take them up or institutions to put on courses
- poor progression between further education (FE) and HE
- demand emerging at postgraduate level, where undergraduate demand is low."

(HEFCE, 2005, p. 8)

Physics, chemistry, maths and engineering were identified as fitting the above criteria and were necessary for the country to sustain economic growth in science and technology: they were deemed 'wealth-creating subjects'.

Although there had been a very slight increase (1%) in physics as a degree subject, other 'hard subjects' e.g. clinical medicine had seen an increase of 38% HEFCE suggested that perhaps this suggested a more vocational bias for many students.

1.1.2 Stimulating Physics structure

A significant part of the support in schools focused on in-house continuing professional development (CPD) for non-specialist teachers of physics. The Stimulating Physics pilot was in effect from November 2006 (where the programme was officially launched at the National Science Learning Centre) to July 2009. The pilot was then expanded into a national Stimulating Physics Network in collaboration with the science learning centres. There are currently 23 teaching and learning coaches (TLCs) who each provide bespoke physics CPD in 12 schools within their region. Further support to other schools is provided by 37 Physics Network Coordinators. The pilot was composed of a demand strand which was focused on school-based support and an access strand which worked with universities to improve access to physics course.

1.1.3 Demand strand

The demand stand was implemented with 28 schools in Leeds, Nottinghamshire and Oxfordshire. These three regions were chosen to represent a range of schools, both inner city and rural in nature, that involved the following support:

Careers-based support alongside the Careers Research and Advisory Centre (CRAC)
There was a regional CPD event to link the work of career and science teachers. The Ashfield Music Festival simulation was designed to run as a one day event in school for a large group of Year 10 students. Throughout the day students work as a team in their designated role, e.g. sound engineer, to produce a plan and pitch to the local council for the contract to stage the music festival. STEM ambassadors were suggested as suitable experts for the students to seek advice from during the planning phase.

Continued professional development for non-specialist teachers of physics

All schools engaged in a series of bespoke CPD sessions that took place in their school, at a time that fitted with the schools' teaching timetable. The level of participation varied from as little as one session to nine throughout the course of the two year pilot. There were also three 4 day long summer schools that took place at Worcester College, Oxford and at the National Science Learning Centre in York.

E-mentoring of school students

This was administered by the Brightside trust and school pupils were recruited by their teachers to enrol on the website bigbangblogs.org. The mentors were physics undergraduate students who had been CRB checked and trained to provide support and information about university life, in addition to discussions about physics via email.

Girls in Physics

Activities with schools included training to raise awareness of barriers for girls and ways of overcoming them; girls careers days; focus groups and questionnaires to evaluate girls only physics lessons; observation of mixed gender physics lessons; support and advice for physics teachers wishing to identify and further develop their 'girl-friendly' classroom practice. In addition, 'girl-friendly' activities were integrated into the teachers' CPD training. Schools in Leeds received targeted support from the UK Resource Centre for Women in SET (UKRC) to aid girls' engagement with physics.

Industrial visits in collaboration with the Industrial Trust

The aim of the industrial visits was to help raise pupil awareness of careers in and from physics. Visits were planned with the lead teacher in each school and where possible this was tailored to the science curriculum. There were some 'girls-only' visits, for example, to a sound recording studio.

1.1.4 Access strand

In parallel with the demand strand, the IOP worked with Higher Education institutions to improve the proportion of students continuing with physics at degree level. Teacher fellows were appointed during the pilot to make links between schools and universities. A new repackaged degree, Integrated Sciences, was developed in collaboration with four universities, in order to appeal to a wider range of students.

1.1.5 Key findings from the Institute of Education's evaluation of the Stimulating Physics pilot in July 2009

The pilot was evaluated by the Institute of Education (IOE). The IOP set a target of a 20% increase in number of students taking A level physics across the planned 5 year programme, this would attempt to redress the balance of the preceding 15 year decline in uptake of A level physics of 30%. The IOE evaluation found that across the 11 schools that provided suitable data for analysis:

- increase of 13% of A level students 2008/09, compared to a 1% decrease in control schools
- increase of 33% AS candidates for the year 2009/10

This research program contacted the pilot schools to collect quantitative data regarding uptake of physics post-16 and arranged focus group interviews with sixth form students regarding their motivation to pursue physics education beyond the compulsory stage.

The following chapter reviews the current literature pertaining to student choice in science post 16, ranging from personal interest to school-based influences. The following themes are discussed: gender; culture; attitude and education.

The methodology is presented in chapter 3: the use of secondary data to augment qualitative methods is discussed, in addition to more traditional data collection method using questionnaires.

Chapter 4 contains quantitative analysis of student uptake of AS and A2 physics in Stimulating Physics pilot schools compared to other schools within the three regions involved. In addition to more traditional questionnaires, an alternative strategy was adopted using secondary data from the National Pupil Database (NPD).

Chapters 5 and 6 present findings from student focus groups and teacher interviews respectively. Schools that had responded to the initial request for data were selected for interviews; these had varying degrees of change in student numbers and participation with the Stimulating Physics pilot. Teachers from both 11-16 and 11-18 schools were interviewed, although Year 12 students were only available in the latter group.

A summary of the research findings is provided in chapter 7, followed by a critique of the methodology employed and recommendations for further research using secondary data.

Chapter 8 details the implications and recommendations for the current phase of the IOP initiative: the Stimulating Physics Network, and has implications for CPD in the 276 schools involved in the programme.

2 Literature review

Physics has an important place in the school curriculum, but it continues to be the least popular science A level, resulting in an inadequate number of undergraduate students to supply the demands of today's technological advanced society (Higher Education Funding Council (HEFCE, 2005) and there remains an insufficient supply of school physics' teachers (Smithers & Robinson, 2008). The Stimulating Physics pilot was developed to improve student uptake of physics within schools and at degree level as a HEFCE funded initiative. The Russell Group's most recent publication 'Informed Choices' (Russell Group, 2011) advises students to select from 'facilitating subjects' in order to access a wider range of degree courses. The eight listed subjects that are required for university courses include the three pure sciences and mathematics.

This research project will focus on the factors affecting student uptake at A level, the school-based 'demand strand' of Stimulating Physics included teacher continuing professional development (CPD) and a number of activities designed to improve pupil engagement with physics.

2.1 The decline in the number of students opting for physics

A key performance indicator in the effectiveness of the Stimulating Physics project is the number of pupils opting for physics post-16. This review of the literature focuses on the factors that have led to the lower than desired uptake of A level Physics in England, a trend that is seen across the western world (Haussler & Hoffmann, 2002; Krogh & Thomsen, 2005; Osborne, Simon, & Collins, 2003; Reid & Skryabina, 2003).

Is it possible to untangle the many threads that are woven together to create a physics enthusiast? What emerges is that how we measure attitude, interest and enthusiasm, key factors in determining whether pupils choose physics is no easy matter (Aikenhead & Ryan, 1992; Bennett & Hogarth, 2009).

Review of data pertaining to A level physics uptake across the last decade

Analysis of data from Joint Council for Qualifications (JCQ) for England from 2001 to 2010 reveals that there has been a small increase (1%) in the number of physics A level entries, compared to the corresponding increases of 13% in chemistry and 7% in biology. Also of interest is the significant dip which occurred in 2005, corresponding to a 9% decrease in physics numbers; this was not observed for chemistry, which remained relatively static or biology for which there was an increase of 2.5%.

The shortfall in the number of students opting for physics at A level represents a decline that has spanned several decades. A review of the literature commissioned by the Institute of Physics (Murphy & Whitelegg, 2006) identified key areas of influence: students' attitudes to physics, including their self-efficacy; teacher effects; curriculum interventions.

The following factors each affect pupils' choice to pursue physics (and science, in general):

- Gender
- Culture
- Attitude
- Education

Within each of the key areas of discussion gender emerges as a recurrent theme. It will be introduced in the following section and then revisited throughout this literature review.

2.2 The effect of gender on pupils' uptake of science

Women are underrepresented in many physics-based careers, university departments, and at the first opportunity they have to take physics beyond compulsory schooling. At undergraduate and A level, approximately 20% are female. In the wider arena of Science, Technology, Engineering and Mathematics (STEM), 29.3% of women graduates are employed within the SET sector, compared to 54.8% of men from the same qualification base (UKRC, 2010). The figures refer to female and male graduates separately. Therefore there are 70.7% of female STEM graduates who do not pursue a career with the SET sector, as opposed to 45.2% of male graduates

Physics has stereotypical image of being white, middle-class and male (Elias et al., 2006) and most examples of physicists that students typically come into contact with fit this criteria. If one examines the language of physics found in GCSE specifications, we are confronted with an array of male scientists from another world: Newton, Joule, Ohm, Ampere, Volta, Coulomb. There is often a lack of role models at home, school and the 'real world' for girls to relate to.

2.2.1 Differences at A level

Analysis of A level results from the JCQ website demonstrates that although the total number of female A level candidates in England has increased between 2001 and 2010, there has been a decline the number of girls opting for physics (-6.8%) and the ratio of male to female students has hovered around its current figure of 3.6:1. For A level biology the ratio remains in favour of the female students, but this has shifted as more male students have opted for the subject of late. For chemistry there is a more equal balance of 1.1:1 males to females. Outside of science, but worthy of note is the dramatic decrease in the ratio for mathematics (from 2.3:1 to 1.6:1), which is often perceived as a masculine subject alongside physics.

The gender imbalance between girls and boys taking A level physics is not a new phenomenon (Gardner, 1975). There have been a number of initiatives to address this deficit of girls in the physical sciences, however based on the above statistics, it would seem that there has been little effect and that we need to examine other factors alongside school science education.

2.2.2 Socialisation

Is there a natural aptitude for physics in boys or can this be ascribed to the conditioning influences of society? Or perhaps both nature and nurture play a role.

Could personality types provide the key to identifying future physicists? A particular set of character traits was found to be evident in girls who pursued physics after a traditional course (Head & Ramsden, 1990). The traits of judging and sensing were significant less evident in male scientists and female artists. An encouraging finding was that this gender difference could be reduced by changing how science is taught.

According to Johnson (1987), the hobbies and interests of young boys and girls differ vastly and have a role to play in the development of a ‘broad consolidating base for conceptual learning in physics for boys’. Boys tended to spend more time finding out about how things work, taking things apart and putting model kits together, whereas girls’ interests leant more towards domestic and caring pursuits.

One would imagine that the range of activities has shifted since then, many children are no longer engaged in ‘wholesome’ outdoor pursuits, but are confined to the ‘safe’ and less exploratory environment of the home affording less opportunity to investigate the physical world first hand.

In the US, physical scientists were interviewed regarding their childhood interest in science (Maltese & Tai, 2010). Most responded that their interest was sparked at an early age, 65% before middle school (age 11). Over half of the male scientists thought their initial interest in science was due to something ‘intrinsic’, whereas the bulk of female scientists attributed this to a school based experience. Of note, is that 24% of women thought that their families had a role in getting them into science, as opposed to 10% of the men interviewed.

It has also been suggested that mothers, in particular, have a key role in encouraging girls to engage with science in their out-of-school interests and to emphasise its worth in career terms via informal discussions. This maternal encouragement is a predictor of girls’ self-perception in science (Bhanot & Jovanovic, 2009). Girls are more likely to make positive comments to their mothers about science than boys (Tenenbaum, 2009); this suggests that they are seeking confirmation from their mothers that is acceptable for a girl to be interested in science.

Parents of boys have a higher perception of their child’s ability than those of girls, and it is unsurprising that this transfers to the boys themselves, even when test scores indicate gender parity (Bhanot & Jovanovic, 2009). When selecting prospective courses for their children at secondary school, many parents conform to stereotypes and are more inclined to select science courses for sons rather than daughters and also offer less encouragement to girls in general (Tenenbaum, 2009), which may in turn lead to girls reduced self-efficacy.

2.2.3 Self-efficacy

Self efficacy can be defined as a ‘can-do and will-do attitude’ and differs from self-confidence or self-esteem in that it includes the attainment of a clear goal alongside belief in one’s abilities (Bandura, 1997).

By the age of 13, girls in the US had a narrower range of science experiences than boys, expressed more negative attitudes, but their achievements were on a par with or above those of the boys (Catsambis, 1995). A belief that they are simply better at other subjects is, in part, responsible for this disaffection with science (Jovanovic & King, 1998). Closer to home, this be verified by reviewing exam results for 2010. Fewer girls were entered for separate sciences, but their performance at A* grade in GCSE physics is 0.1% above that of boys. (JCQ, 2010).

The seemingly fragile nature of girls’ self-belief with regard to studying physics implies that a higher level of support is required and that teaching should be tailored to include strategies that are less threatening for all learners (Ponchaud, 2008). Strategies that work for girls are also effective for boys who have similar difficulties in engaging with physics (Haussler & Hoffmann, 2002). Any intervention to encourage more girls in physics should not be at the expense of the boys.

2.2.4 Single sexed schooling – effect on self-image and attainment

It would appear on initial inspection that girls educated separately from boys perform better in physics. However, it has been asserted that the mere introduction of a single-sexed learning environment does not fully account for this higher level of achievement and that it is more closely linked to the type of school and its selection criteria, in addition to the socio-economic groups that typically attend such establishments (Elwood & Gipps, 1999; Smithers & Robinson, 1995). When a direct comparison of girls in co-educational and single-sex comprehensives was made there was no such disparity in performance (Smithers & Robinson, 1997).

Somewhat contrary to the above view is the evidence that that girls experiencing single-sex physics instruction have a more positive physics self-efficacy than those in co-educational groups (Kessels & Hannover, 2008). This can be explained by the fact that students use gender as a means of differentiating themselves within the mixed social setting of the classroom. Having ready access to ‘gender-related self knowledge’ leads to a diminished self-concept in ability for girls in more ‘masculine’ subjects, for example physics and maths. In a smaller scale study involving one school (Gillibrand et al., 1999), female students who were taught in a single-sexed group were significantly more likely to choose physics A level compared to their co-educated counterparts. One might argue that a school science department that has recognised the need for intervention and has implemented separate teaching groups is more likely to employ a range of teaching strategies that are more suitable for girls and deviate from the traditional less-engaging style in which physics if often taught.

Rather than aiming for an ambitious overhaul of teaching practices, Ponchaud (2008) suggests small-scale changes that can dramatically affect the teaching and learning experience for girls. These approaches have formed the framework of the action research conducted in schools by the Institute of Physics and in turn have been used with the pilot schools in Stimulating Physics.

2.3 Culture

Elias et al., describe a ‘leaky educational pipeline’ (2006, p. 2) and explain that along each stage of progression from compulsory schooling through to PhD level at university there are dramatic discrepancies between ethnic groups. Following analysis of DfES, Youth Cohort Study (YCS), and Higher Education Statistics Agency (HESA) data from 2004, the most notable findings were that Chinese students are three times *more* likely to pursue A level physics than their white peers, and more dramatically, black Caribbean students, are six times *less* likely to pursue A level physics. The trend is already evident in KS3 science, where the difference in achievement of ethnic groups has started to emerge. This gap widens as students move to GCSE, and black Caribbean and Pakistani students are seen to ‘fall at the first hurdle’ (Elias et al., 2006, p. 3). Before there is the opportunity to choose physics, these ethnic groups are already out of the equation. Of those who are eligible for further study, black Caribbean students have the strongest disinclination to study science at A level. Perhaps as a consequence of the bias towards arts, social sciences and humanities subjects at degree level, traditional science A levels are not seen to be relevant to career aspirations. Career plans have a strong influence on other ethnic minority groups, hence the popularity of A level chemistry among Asian students, a requirement for medicine, dentistry and medically-based disciplines. Greenfield (1995) found that the influence of ethnic origin was found to be more significant than gender.

2.4 Attitudes to science

The view of the current government is that ‘countries whose pupils achieved most at science and maths were not necessarily the ones whose children had the most positive attitudes to the subjects’ (Commons Select Committee, 2011). However, according to science education literature, attitudes to science have a key role in the low uptake of science at A level (Bennett & Hogarth, 2009) and should not be disregarded.

There has been long-standing concern regarding attitudes to science. In their review on Attitudes towards Science, Osborne et al. (2003) identify that this is an issue that has been under consideration for several decades and refer to the ‘swing from science’ (Ormerod & Duckworth, 1975). This cohort of students has gone on to form a large proportion of the parents of today’s pupils who display a similar aversion to learning science (Osborne & Collins, 2000).

Before embarking on an assessment of ‘attitudes to science’ a demarcation should be made between ‘scientific attitudes’ – a scientific approach to thinking, a quest for knowledge and understanding and ‘attitudes towards science’. The latter includes ‘the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves’ (Osborne et al, 2003, p. 1053).

A decline in positive attitude toward science occurs during Key Stage 3 science (Bennett & Hogarth, 2009; Osborne et al., 2003). A study in Scotland, where there is a comparatively healthy ratio of 2:1 (boys to girls) at higher level, indicated that this occurred at the end of the second year of secondary school and was more pronounced for girls (Reid & Skryabina, 2003). Surveys on attitude over the last 30 years indicate that attitudes are ‘much more negative’ for the physical than biological sciences (Bennett, Lubben, & Hogarth, 2007).

Haussler and Hoffmann (2002) measured pupils’ interest in physics lessons at the end of the 5^{th} and 10^{th} grade for 8000 students. Over the course of 5 years, boys’ interest in physics lessons remained constant at 60%, for girls the figure fell from 40% to 20%.

Context has a highly significant role to play in maintaining girls' interest and they are very sensitive to a change of context. It was shown that what girls find interesting also appeals to boys, but the reverse is less likely to be the case. The work identifies the need to differentiate between 'interest in physical matters and interest in physics as a school subject' (p. 448) when assessing pupil attitudes akin to Gardner's (1975) earlier demarcation between 'school science' and 'science in society'.

Krogh and Thomsen (2005) researched attitudes in Denmark, where the decline in students opting for A level physics follows the trend in the Western world. It is asserted that the following were key areas of influence:

- Personality variables – science self-concept;
- Classroom variables, e.g. teaching style; and
- Structural variables – family social and economic background.'

(Krogh & Thomsen, 2005, p. 282)

By discussing these factors in isolation researchers are able to make quantitative evaluations; however, the 'subtle interplay' between each of the factors in the formation of attitudes is lost. Other research has pointed to lack of depth afforded by solely examining the 'most apparent attitudes' (Potter & Wetherell, 1987).

If attitudes are developed by subtle mechanisms over a prolonged period in the child's development, it is unlikely that a simple Likert scale response questionnaire to a selection of statements about science will yield a round explanation of what really is going on between the ages of 10-14 where there is such a dramatic demise of pupils' positivity towards studying science in school. An improvement, developed by Bennett and Hogarth (2009) and based on a previous study in Canada (Aikenhead & Ryan,

1992) probed the students' responses to an initial questionnaire regarding science education and interaction with science outside the classroom. There were separate responses for biology, chemistry and physics and in a subsequent stage of the data collection process students qualified their responses to the initial stage of the questionnaire, using fixed and free responses. This format explores the reasoning behind the first layer of responses.

The proportion of students disagreeing with the statement *'If I had a choice I would study physics'* (Bennett & Hogarth, 2009, p. 1980) rose from 42% in Year 7 to 67% at Key Stage 4. For those who disagreed, their rationale included that it was not needed for the job they were interested in; they could get better grades in other subjects; and the widely accepted belief that physics is hard subject (this was not seen as an explanation for not wishing to pursue biology or chemistry if given the choice). This viewpoint is supported by the fact that 71% of Key Stage 4 respondents thought that a dislike of physics lessons led them to disagree with the statement *'Science lessons are among my favourite lessons'* (Bennett & Hogarth, 2009, p. 1980)

It emerged from the study that twice as many boys as girls would choose physics; the reverse is seen to be the case in biology. For those who would choose physics, 84% of boys cited interest in the subject, as opposed to 55% of girls. Ten times as many boys selected 'I like the maths in physics' as a motivation to select physics.

A preliminary report into the attitudes to science amongst students aged 10 and 11, uses a lens of identity to examine how pupils shy away from the idea of being a scientist (Archer et al., 2010). At a crucial point in the transition towards adulthood, where young people are becoming increasing concerned with their appearance and sense of identity, a career as a scientist seems to chime a death knell for anyone aspiring to be cool. There is a clear, unsurprising, reluctance to join this particular group. Perhaps pupils are seeking to define their identity after adjusting to the challenges of joining secondary school? It is at this important stage that pupils, especially girls, disengage with physics and as a consequence vote with their feet at the earliest opportunity.

2.5 School science education

The cognitive switch between an everyday view of the world and that typified in science lessons has been deemed equivalent to a 'cultural border crossing' (Aikenhead & Jegede, 1999, p. 269), at which existing ideas are exchanged for a new science currency that will buy the student exam success, but may do little to encourage or enthuse them along their way (Aikenhead & Jegede, 1999). This places huge demands on both the pupil and teacher, given that a science class represents a small fraction of a student's working week, leaving aside other external influences – is it a tall order to instil this new culture in such a short space of time?

2.5.1 Curriculum changes

A shift towards a balanced science curriculum occurred alongside the introduction of the GCSE qualification in 1986 (Millar, 1988). Partly fuelled by the drive to increase the participation of girls (Osborne et al., 2003), the change was very successful in raising the number of girls taking science at GCSE. However, this had little lasting effect on the numbers of girls pursuing physics A level. It was also countered in the review that curriculum change did little to alter attitudes.

A significant change to the secondary school science curriculum has included context-based learning (Bennett et al., 2007). More recently, the science curriculum at GCSE has been redesigned to account to include social relevance. The 'How Science Works' element of the curriculum and OCR's Twenty First Century Science have been introduced to improve science literacy, provide a link with today's technological advances and present the 'big picture' about science, putting it in its social context. Both approaches foster the relevance message which seems key in getting girls interested in physics (Head & Ramsden, 1990; Ponchaud, 1998) and it is reasonable to infer that an increased participation of girls at physics A level may result (Bennett et al., 2007).

2.5.2 Practical work

Barmby et al. (2008) observed that a decline in attitudes to learning science in boys from Year 7 to Year 8 that closely matches that of the girls, however this downward trend is curtailed as boys' attitudes to practical work significantly increases throughout KS3. For girls, the smallest decrease in 'science interest' occurs for practical element. It would seem that the practical nature of science is the most appealing aspect of school science and that efforts could be made to ensure equal access to for girls, including assignment of girl only groupings and rotation of roles within each group and of equipment. However, the three physics' practical activities that take place in the 'Lab in a Lorry' would lead pupils to comment on this aspect of science in particular, although from their questionnaire responses it seems that practical work has a key role to play in enhancing a positive attitude towards school science.

Interest in practical work is a vague term and what constitutes interest is frequently used interchangeably with motivation; 'interest doesn't imply cognitive engagement with any, or all of the intended ideas/concepts' (Abrahams, 2009, p. 2340). Interest in this sense, is 'situational' – in that it arises as a consequence of being in a particular environment – in this case the science laboratory - and has an ethereal quality, as once the pupil is removed from the laboratory, the interest is gone. Novak (2002) asserts that situated learning is 'at a lower level of meaningful learning' and as such forms non-transferrable knowledge.

Teachers may use practical work as a 'quick fix' in order to raise pupils' immediate enjoyment of their lessons, leading to improved behaviour especially among lower ability pupils. This may lead pupils' ideas away from an appreciation of the intellectual challenges afforded by science, problem solving and reasoned, logical thought. The very immediacy of the practical tasks may tend to induce a surface understanding of what science is really about and could underpin pupils' ideas about science careers often involving working in a laboratory – as exemplified by pupils' descriptions of scientists (Archer et al., 2010).

By the end of Year 7 approximately half of the pupils use 'relative preference' as a rationale for liking practical work, this rises to 87% by Year 11. It is not that pupils particularly enjoy practical work, it is the lesser of two evils, when pitched against written tasks. Perhaps the perceived gender difference observed by Barmby et al. (2008) is a reflection of boys' reluctance to engage in writing. Abrahams (2009) did not investigate the effects of gender, but it would be of interest to examine if there was a correlation with literacy ability and relative preference of practical work.

2.5.3 Teacher effects

The effect of the teacher has a significant bearing on students' attitudes to school science and their subsequent choice to pursue science (Simpson & Oliver, 1990; Myers & Fouts, 1992; Woolnough, 1994).

There is a widespread notion that physics is hard subject (Bennett & Hogarth, 2009). Teachers frequently cite a lack of mathematical ability as a barrier to students pursuing physics further (Murphy & Whitelegg, 2006).

As science has become a compulsory subject there is less pressure on teachers to sell their subject to the students or to elucidate its cultural value (Munro & Elsom, 2000). Many schools selected pupils for triple award science on the basis of ability at Year 9, which does not allow for pupil choice. The value of science as an essential part of society and suitable career choice may be overlooked as recruitment efforts are concentrated on 'option subjects.'

The co-education delivery of science in schools was seen to be 'an extremely subtle form of unequal treatment' (Haussler & Hoffmann, 2002, p. 447). The curriculum and mode of teaching and how the subject is taught by male and female teachers alike are mainly influenced by the interests, knowledge and abilities of the boys (Haussler & Hoffmann, 2002).

As male students attract more attention than their female counterparts and are also more inclined to initiate contact with the teacher (Crossman, 1987), adopting a more interactive approach to physics teaching reaps benefit across many age ranges, and has been found to reduce the gender gap in undergraduate students in the US. This 'in-class interaction, helps reduce competition, foster collaboration, and emphasize conceptual understanding and increased understanding for male and female students and reduces the gender gap' (Lorenzo, Crouch, & Mazur, 2006). Physical scientists are more influenced by the 'quality of teaching, personal encouragement, nature of the subject, its practical, human and intellectual nature.' (Woolnough, 1994, p. 669).

The rapid decline in pupil attitudes to school science between the ages of 11 to 14 years, could be a direct consequence of the higher degree of teaching by non-specialists at this key stage, who may be unable to convey genuine enthusiasm and subject loyalty. Teachers outside their specialism are seen to lack confidence both in their subject knowledge, use of equipment and often resort to 'teaching by the book' using restricted teaching strategies (Kind, 2009). Millar (1988) identified non-specialist teachers' lack of confidence with many aspects of physics teaching, including a reticence to engage in practical work with unfamiliar or temperamental pieces of equipment. Cited as most problematic were cathode ray oscilloscopes and electricity experiments.

2.5.4 Recruitment and retention

In 2006, 23.8% of schools in the UK did not have a physics specialist teaching in the department (Smithers & Robinson, 2008). This figure was reported at 50% for inner-London schools. There was a net decline of 115 physics teachers (26%) during 2006 and this has been mirrored by the decline in pupils opting for the subject. Retirement was seen to be the main reason behind teachers leaving physics. Moor et al. (2006) reported that the proportion of science teachers whose 'highest post-A-level qualification in science was a degree in physics' was 10% (p. 132). This is not the case in Scotland, where physics is taught chiefly by subject specialists and there is a healthy uptake of physics beyond 16 (Reid & Skryabina, 2003). Given the 'Catch-22' situation of an inadequate supply of undergraduate students in the pipeline to become physics teachers, an alternative approach is to provide continuing professional development (CPD) for existing non-specialist physics teachers, for example, Science Learning Centres through short courses, the current Science Additional Specialism Program (SASP) and the school-based support offered by the Institute of Physics' Stimulating Physics Network. SASP is a 40 day programme that retrains existing science teachers to teach to A level standard. In a review of non-specialist physics teaching, Millar (1988) stated that 'the findings suggest that in-service physics education for science teachers should be school-based, and grounded in a constructivist model of teachers' learning in science.' (Millar, 1988, p.39).

2.5.5 Summary

There is a decline in positive attitudes to school science during the first three years of secondary school, this is most noticeable for girls and physics has the least positive attitudes associated with it (Haussler & Hoffmann, 2002; Osborne et al., 2003; Reid & Skryabina, 2003). Although the decline in the numbers of students taking physics at A level seems have been halted in 2009 and 2010, there is still smaller proportion of students taking physics at A level relative to biology and chemistry.

Therefore, there is a very convincing case for targeting any interventions at students, especially girls, when they are in the early years of secondary school. Once they have decided that science (and physics) is not for them it is difficult, though not impossible, to change their attitudes (Reid & Skryabina, 2003). This departure from science comes at crucial time in development of self-identity, and needs to be managed in a sensitive manner. It would seem sensible to focus on teachers at Key Stage 3 who are often non-specialists and may lack the necessary confidence in content knowledge and practical skills to pass any enthusiasm onto the students (Millar, 1988).

3 Methodology

This research project assessed the impact of the Stimulating Physics programme using a mixed methods approach: quantitative data on student numbers in post-16 physics courses was analysed; focus group interviews with current Year 12 students and interviews with teachers were arranged in a cross-section of schools that had varying degrees of change in student uptake. Focus group interviews with students were used to reveal factors contributing to their decision to pursue physics post-16. Teacher interviews were used to review if there had been an enduring change in their individual teaching of physics and at an organisational level within the school science department. The teachers provided another perspective on the impact of the pilot, in addition to that of the students and this combination of methods triangulate the study (Bell, 2010; Cohen et al. 2007; Gorard & Taylor, 2004). Any commonalities between schools where there has been a similar degree of change in uptake or indeed participation should emerge from careful analysis of the qualitative data.

Schools that participated in the pilot study were evaluated by the Institute of Education in July 2009. The aim of this project was to assess the impact of the Stimulating Physics project post intervention and to analyse the results with respect to gender. As a modification and improvement to the initial research design, secondary data from the National Pupil Database was used to supplement data collected from the schools regarding student uptake from 2006 to 2010. Semi-structured teachers interviews included sections on direct teaching, departmental changes, whole school involvement, changes to the students.

Although this thesis is principally concerned with data from the pilot stage, it was hoped that a formative assessment of the 'success factors' would be possible and that this would inform practice with the existing phase of the stimulating physics network.

3.1 Research Questions

1. What impact did the Stimulating Physics pilot have on total numbers of students taking AS and A2 physics?
2. How did changes in uptake differ for girls?
3. How did this compare with other control schools in the same regions?

These questions can be answered by quantitative methods but it would not be possible to assess any subtle changes in the attitudes of the students and teachers of physics. This project sought to investigate how the participating schools have been affected by their involvement. In addition to quantitative analysis of student numbers, interviews with students and teachers were used to explore further changes within the school's science department. Bennett (2003) suggests that a multi method approach "permits exploration of both the outcomes and processes...what is happening and why" (Bennett, 2003, p.45). Had the teachers involved made any enduring changes to their physics pedagogy? What did they feel was effective within the support programme?

Guskey (2000) provides a useful theoretical framework, identifying 5 critical levels of "professional development evaluation:

1. Participants' reactions
2. Participants' learning
3. Organization support and change
4. Participants' use of new knowledge and skills
5. Student learning outcomes"

(Guskey, 2000, p.82)

As the pilot stage of the project finished in July 2009, it was not possible for a realistic measurement of participants' reactions to be made; this is typically assessed immediately after completion of a session either in school or at a summer school. The main focus of this research was on level 5: student learning outcomes, including uptake and attainment at AS and A level.

Levels 2 to 5 would be evaluated by:

Quantitative data: Pupil attainment pre- and post- intervention

Change in the number of pupils choosing to study physics.

Qualitative data: Pupil attitudes to physics and their physics lessons via semi-structured focus group interview.

Interview with teachers regarding their confidence and use of new skills

3.2 Overview of pilot schools

There were 28 schools that fully participated in the Stimulating Physics pilot and these were based in three regions, comprising of the following local authorities: Leeds; Nottingham City and Nottinghamshire, and Oxfordshire. Schools were selected from analysis of school data including GCSE average scores, numbers entered for GCE and UCAS point scores. Local authority advisors and Aimhigher were also consulted in each region and regularly attended regional working group meetings with other stakeholders from the Industrial Trust, the Careers Research and Advisory Council, and the UKRC. Schools in each region, therefore fit one of the following criteria:

- 11-16 school, where students are less likely to continue their physics education at 6^{th} form level

- Poor A level physics uptake in 11-18 schools

- Continuing poor recruitment on degree courses – schools where A level physics students were not pursuing physics at degree level

There were twenty three 11-18 schools, five 11-16 schools and one sixth-form college. In each region a specialist science college was included, in order to facilitate regional events, e.g. Girls in Physics training across the region. One of the 11-18 schools in Leeds dropped out of the program after two terms as the Head of Department felt they were under too much pressure elsewhere in school to continue.

Initial Sample

Due to the inherent difficulties with tracking students from 11-16 schools to their destinations, the initial sample consisted solely of the twenty-four 11-18 schools. All of the schools were comprehensive, apart from one ‘other maintained’. One girls’ school and one boys’ school were included in the sample.

3.3 Collection of school data

Questionnaires regarding student participation in post-16 science had been piloted in November 2010 with current Stimulating Physics Network schools. A refined version was sent to 11-18 SP schools and, based on data returned, schools were selected for interviews. It emerged from the quality and low return rate of the responses that an alternative means of obtaining the data would be necessary. Secondary data sources have been used within education research, although there have been few studies published adopting this approach and there are concerns among the academic community due to the inherent errors associated with large datasets (Gorard & Taylor, 2004; Smith, 2008). However, the National Pupil Database has been used recently to investigate how successful schools encourage uptake of physics and chemistry in post-compulsory education (Bennett, Hampden-Thompson & Lubben, 2011).

Questionnaire design and implementation

To analyse the impact of the Stimulating Physics pilot a longitudinal measure would require student uptake data at AS and A2 from 2006, before the intervention, through to 2010 (the current academic year).

It was hoped, that due to the pre-existing working relationship that the Institute of Physics has with the pilot schools, that there would be a higher response rate than normally expected, which can be lower than 50% in many cases (Muijs, 2004). However, a well-structured sequence of follow-ups as used by the Office of Population Census and Surveys can boost response rates from 40% to 75% (Cohen, et al., 2007, p.346).

Piloting the questionnaire and refinements

The response table had been altered to request exact figures for students starting both the AS and A2 courses and tested with the current phase of the Stimulating Physics Network (see Appendix A). There was a 60% response rate from the 11-18 schools that are currently supporting in Leeds, York and North Yorkshire. The questionnaire was adjusted for the purpose of this research project to include gender and the GCSE exam specification followed by the students.

Inclusion of gender

As discussed in the literature review, there is an issue with the number of girls studying physics and the pilot study employed strategies to address this. Therefore, data for girls and boys starting the science subjects was requested.

Exam specification

The spreadsheet version of the questionnaire included a drop-down menu listing the GCSE exam specifications, respondents selected the relevant specification taken by the AS cohort. This was to provide an additional filter for the effects of 21st century science. It was found that following the 21st Century Science GCSE there was an increase of 38% in the numbers opting for AS level physics (Millar, 2010). Collection of exam specification data would help identify whether a change in student numbers is due to Stimulating Physics, 21st Century Science or a combination of the two.

Review by teachers

The reordered questionnaire was reviewed by three experienced science teachers and table headings adjusted to highlight the request for both AS and A2 course data.

3.3.1 Initial data collection programme

The original plan was to collect data and arrange interviews before the Easter break, according to the outline in Table 3.1.

Table 3.1: Initial data collection programme

By end of half term (25th Feb)	Participation questionnaires emailed and posted to schools.
2nd March	Follow up phone calls for non-responsive schools.
7th March	Analyse data and select schools for focus group interviews.
14th March	Letters to head teachers and Head of Science for interviews Phone to arrange dates with HoD
21st – 31st March	Student focus group interviews.
April onwards	Analysis of qualitative data.

3.3.2 Administration of questionnaires

There was a slight delay with securing details of the new contacts across the three regions, as many lead teachers had moved to other schools. Hence the initial contact was on 14th March (the lead teacher email can be found in Appendix C):

1. Update list of Head of Department and School contacts by contact with IOP teaching and learning coaches (TLCs).
2. IOPs TLCs sent email messages to alert the recipients of imminent contact.
3. Questionnaire and covering letter sent via 1st class mail with an enclosed SAE (1st class) and my business card to enable enquiries by phone.
4. Follow up email sent if no response within a week, with additional copy of questionnaire.
5. Any non communicating schools telephoned to check that questionnaire had been received.
6. Further contact post Easter break due to many teachers requesting this.

More immediate and productive responses were returned from Leeds region, where there had been direct contact with the science departments. It emerged that there had been a large staff turn-over and many teachers that participated in the pilot have since moved on. This meant that effectively some of the questionnaires were going out cold.

3.3.3 Obstacles

The questionnaire specifically asks for numbers starting a particular course; this is highlighted in bold on the document. It emerged that most schools do not keep formal records of numbers starting a course. Many of the teachers spoken to directly explained that they would use their personal records, and occasionally there were records for the whole science department. More generally, acquiring data involved the school lead teacher seeking out records from the subject teachers. Hence, some questionnaires were returned with data missing from either biology or chemistry. There were several incomplete responses:

- Missing data from a particular year
- Missing gender breakdown
- No response from chemistry or biology (it is reasonably time consuming for a teacher to search through their records, perhaps with little obvious benefit to those not teaching physics).

It became clear that most science departments do not keep formal records of the number of students starting each course in Year 12 for any length of time. There were a few exceptions, but in most cases obtaining the data required a significant effort on their part or some stated that they do not keep records this far back and returned exam entry data. The Easter break fell at different times for each region, which led to a mismatch in teachers' availability for response and follow up.

Many were 'busy with coursework deadlines' and felt they were not in a position to respond to reply until after the Easter break. There is a high staff turnover in the schools that were involved in Stimulating Physics and this meant that the working relationship that had been established had ceased.

3.4 Modifications to methodology – the use of secondary data

After reviewing the inconsistent data supplied by schools, it was decided to investigate using the National Pupil Database (NPD) to acquire exam entry/attainment data for each of the schools in the pilot. Bennett et al. (2011) had analysed data for pupils taking A level physics and chemistry in 2008. They reviewed characteristics of schools where there was an above average uptake and by mapping with similar schools, were able to isolate factors that characterised success in the schools. This quantitative analysis was combined with qualitative methods. Gorard (2002) discussed how the "poor public image of UK educational research" (p. 231) may be improved upon by the use of secondary data and highlighted its suitability for a Masters' timetable of research as the analysis can be conducted over a short time scale.

The initial methodology was to compare changes student uptake in physics with those in biology and chemistry within the pilot schools. However, access to the NPD would permit the analysis of data across *all* the educational establishments in the pilot regions at the individual school level. Therefore an independent samples t-test was conducted across the two groups (SP and control schools) with regard to changes in physics' uptake from 2005/2006 to 2009/2010.

3.4.1 Accessing the National Pupil Database

It would have been reasonable to expect a similar response rate to the IOE in their evaluation, where 28.9% of schools provided a response. In fact, although 8 schools (33%) completed the questionnaires; only one response was complete across all subjects and for all the year groups. As the questionnaire had been tested with the schools that are currently involved in the Stimulating Physics Network and had a 60% return; this was a disappointing response rate from the pilot schools.

Permission was requested from the National Pupil Database as this was an alternative and more extensive source of data. Pupil records include details on age, gender, school and local authority references, which were matched on academic attainment. Data for KS4 and KS5 attainment was requested from 2006 through to 2010. The NPD were also sent access request documents, which detailed the research aims and the target audience. On initial inspection this may seem a more lengthy process, the NPD state that most requests will take approximately six weeks to process. However, this was on a similar timescale to sending, following up and inputting the questionnaire data.

The original request was for data on the 28 schools in the pilot. As each pupil has an individual pupil matching reference, they can be tracked throughout their school career. This opened up the possibility of matching students from 11-16 schools with their 6th form destinations. More detail on the data requested for analysis is included in Appendix B.

After attending a course on using the NPD at the Institute of Education it emerged that a more rigorous approach would be required to compare changes in physics' uptake in the pilot schools with the remaining schools in the respective regions. Therefore, an additional request for data on all the relevant establishments in each of the four local authorities was made.

The pupils were tracked to back from their KS5 establishment to their KS4 school using a series of linked tables in Microsoft Access. All the Key Stage 5 data includes AS entries for Year 12 and Year 13 students and this was filtered to remove Year 13 students from the AS pool. An independent samples t-test was used to compare percentage uptake of AS and A2 physics in pilot and control schools.

3.4.2 Anomalies

As the data returned from phase one included one school where the numbers had dropped significantly the regional advisor from the IOP was contacted to discuss this school. The school had been in special measures, as a consequence all the science uptake figures had dropped and so this school was removed from further consideration.

3.5 Qualitative methodology

'the detail and richness of the information collected through interview is usually impossible to attain from analyses of records, minutes of meetings, or questionnaires.'

(Guskey, 2000, p. 172)

3.5.1 Selection of schools for interview

On the return of the questionnaires schools were to be selected on the basis of their responses for focus group interviews with sixth form students regarding their reasoning behind their subject choices at A level. Three schools were selected for interviews and included a school from each of the following groups:

- Schools that have increased participation
- Schools that have the same level of participation
- Schools that have a decreased level of participation

As a teaching and learning coach on the existing programme the researcher had a CRB check for the schools concerned and the schools have had a close working relationship with the IOP, both of which facilitated access. However, letters were sent to the head teachers of the school to request their permission (see Appendix D and E).

3.5.2 Student focus group interviews

Group interviews with students would allow exploration of what led them to make their choices. Did Stimulating Physics have an effect on their decision making and did they recall any relevant classroom practice or other activity that had a positive effect on their learning experience? Questions to be considered have evolved from attitudinal research by Bennett and Hogarth (2009). Factors that warranted investigation include: teacher effects; outside interests; careers plans. I was also interested to ascertain the age at which students thought of pursuing physics and if there was a particular event or person who was behind this. Students were asked how they thought more students could be encouraged to take physics further and when any initiatives should take place.

3.5.3 Trial of student interviews

Interviews were trialled with schools currently involved in the Stimulating Physics Network and a local college of further education, questions were refined and there were opportunities to gain familiarity with the new recording technology afforded by the iphone 'Audionote' application. It was hoped that using a mobile phone was less intrusive than a laptop. The software allows notes to be made during the recording as placeholders, thus improving the efficiency of transcribing. Within the two groups it became apparent that careful management of contributions from all groups was required as some were less inclined to contribute than others. Refreshments were provided, which proved an incentive for some students. The research aims were explained at the start of interview, and it was stressed that there would be complete anonymity for the students. Based on the trials, the groups were limited to 3 or 4 students, either single-sexed groupings or as balanced as possible. Hayes (as cited in Bell, 2010) suggests that due care over the balance of gender is taken when planning group interviews and that a single-sex group may be more accommodating and help the interviewees to feel more relaxed.

3.5.4 Revised selection of schools for interview

The selection of schools for interview was revised to include schools where there had either been significant change or where no obvious change in figures had occurred. There was only one school where there had been a decrease in student numbers and there was only one student taking physics at AS level, therefore this school would not be appropriate for the group interview schedule planned. The sample included an 11-18 school where there was no physics specialist, but the students had opted for physics at AS level. Although the 11-16 schools are more likely to be lacking a physics specialist (Smithers & Robinson, 2008), it would not be possible to interview the physics students due to the tracking issues mentioned previously.

Interviews were conducted after AS exams, which was later than initially planned. The initial timetable was reliant on a speedy return of data from the lead teachers, however, they were focused on GCSE coursework deadlines, prior to revision. Letters of consent were posted and emailed to the head teacher and a copy of the researcher's CRB check was subsequently sent.

Interviews with students were conducted in three comprehensive schools with Year 12 students taking physics AS level. This was not a randomized selection, as it is clear that coordinating interviews requires a great deal of cooperation on the part of the school and this will only take place where there are good lines of communication. A total of 17 students were interviewed, including two single sex groups and three mixed groups (a copy of the schedule can be found in Appendix F).

3.5.5 Teacher interviews

Continuing Professional Development (CPD) played a central role in demand strand of the Stimulating Physics pilot. Schools participated in regular, in-house CPD that often involved the whole department, in addition to attending summer schools in Oxford and York.

Teacher interviews were used to provide a detailed account of the effect of Stimulating Physics on the pedagogical and subject knowledge of the individual, and allowed discussion of changes that had arisen in classroom practice and more widely in the science department. It was intended, through discussion with the teachers, to gain some insight into what made the Stimulating Physics project more successful in some schools than others. Part of the interview schedule would be used to gauge whether teaching strategies and pupil engagement activities had become embedded two years after the end of the pilot.

A total of 7 teachers were interviewed. The interviews were conducted in two 11-18 schools following student interviews and separately interviews in two 11-16 schools. Interviews took place late in the summer term after public exams. An interview schedule can be found in Appendix G, the following key areas were discussed:

3.5.6 Teacher involvement in the program

Teachers were asked about their physics teaching background and to what extent had they been involved in Stimulating Physics. They were asked about changes in the classroom: pupil behaviour and engagement; teaching strategies and teacher confidence. Included was a probing question: ‘What advice would you give to a Year 11 student who thinks physics is too hard?’ This was used to gauge how effective the careers’ aspect of the program had been, and used this question as a measure.

Organisational change

Had there been any changes across the department and beyond as a result of participating in Stimulating Physics? Had any whole school activities developed as a consequence of the student engagement projects that took place?

3.5.7 Implementing a CPD program in schools

What advice they would give to another school embarking on the project? This gave them an opportunity to reflect on what would they have done differently. How could they be further supported by the Institute of Physics?

The results of the quantitative and qualitative methods that have been discussed here will be presented in the three separate results chapters that follow.

4 Quantitative Analysis of student uptake data

My hypothesis was that involvement in Stimulating Physics leads to an increase in pupils opting for physics post 16 when compared with similar schools within the same local authorities.

This chapter will examine changes in student uptake during the Stimulating Physics pilot and beyond. Unfortunately the response rate from Stimulating Physics (SP) schools was lower than anticipated, analysis of the schools' data in isolation would be limited to the 9 schools and therefore it would be difficult to draw any meaningful conclusions. As part of the research seminar programme at York, I became aware of a study using the National Pupil Database (NPD) to identify schools that were successful at recruiting students to physics and chemistry (Bennett et al., 2011). The NPD collects longitudinal data for all pupils obtained in the Pupil-Level Annual School Census. Therefore data was requested from the NPD for KS4 and KS5 exam results for the four local authorities involved in the SP pilot. This would enable analysis of all the SP schools and the non-SP (control) schools in the regions; and allow for variations in student population.

4.1 Selection of data

4.1.1 School questionnaire responses

The school-supplied data was useful for a reference point for interview selection and it was extremely useful to have the schools' data as a safety-check for case-selecting procedures.

The initial approach that required schools to return records from 2006 onwards was overly optimistic in that most schools did not have easy access to student data and it took a considerable amount of time to elicit a response from them. The schools that responded most quickly were those that I had worked with directly: although one of these was a very clear negative. The teachers obtained the data from their own personal records or those of the exams officer. Of course, exam data differs from the ‘numbers *starting*’ that was requested on the form. It would appear that most science departments did not rigorously monitor the number of students starting a course and pursuing AS subjects through to A2 beyond a few years.

4.1.2 Tracking post-16 students

The use of NPD data allows pupils to be tracked back to their original KS4 establishment. All figures will be based on the KS4 establishment attended by the AS and A2 level students. This is of particular interest as it allows the effects on 11-16 schools to be examined, where there is often a lack of specialist physics teacher within the department (Smithers & Robinson, 2008). For 11-18 schools there is still an issue with tracking pupils who have left their original school to pursue 6th form courses elsewhere. However, each pupil has a unique matching reference number it was possible to trace them to their destination school or college in the Key Stage 4 records that had also been requested.

4.1.3 ‘Missing’ AS data

Student interviews were arranged based on the level of response from the school and their replies to the student uptake survey (Appendix A). On initial inspection the data for school C was missing Year 12 students from 2008/2009 and 2009/2010. I then inspected the national data for all students across all subjects and found that there were 18,000 students missing from Year 12 (2008/2009) who were in the Year 13 (2009/2010) dataset for the following year. Inquiries with the NPD revealed that the ‘missing’ students arose from the fact that some schools chose not to ‘cash in’ the AS level qualification for the Year 12 students and had therefore not activated the trigger for inclusion in the dataset. Students who ‘cash in’ gain an AS qualification in Year 12, others who are continuing with the course to A2 may delay until Year 13 which provides an opportunity to resit modules. However, this situation is less likely to present itself in future analyses, due to changes in funding that will lead more schools to ‘cash in’ their AS qualification (Ofqual, 2011).

Table 4.1: Year 13 A level student figures for City of Nottingham, Leeds, Oxfordshire and Nottinghamshire for all subjects (accessed from the National Pupil Database)

Year 13 academic year	2006/7	2007/8	2008/9	2009/10	TOTAL
Number of Year 13 students	13240	13530	14765	10949	52484
Number of Year 13 students present in Year 12 dataset	9017	9146	9295	7402	34860
Missing students	4223	4384	5470	3547	17624
% of Year 13 students present in Year 12 dataset	68.1%	67.6%	63.0%	67.6%	66.4%

To gain an appreciation of the scale of the ‘missing students’ I used the whole of the NPD data supplied for the four local authorities covered by Stimulating Physics, which includes all subjects taken at AS and A level. Table 4.1 shows a comparison between the total number of Year 13 students that are in the database to those that also feature in the Year 12 records for the preceding year. These figures illustrate that there is a significant portion (33.6%) missing from the AS data, i.e. that have not ‘cashed-in’ their AS qualifications at the end of Year 12. Any attempt to make comparisons of AS data would be limited due to the missing data and Ofqual’s finding that higher achieving students tended to be missing from the results (Ofqual, 2011).

The ‘cashing-in’ policy varies between schools and poses a significant hurdle to analysing student uptake of physics in Year 12. In the case of school C, they had already provided Year 12 data in their survey response. However, in order to use the NPD effectively I planned to follow the steps outlined in Figure 4.1 below:

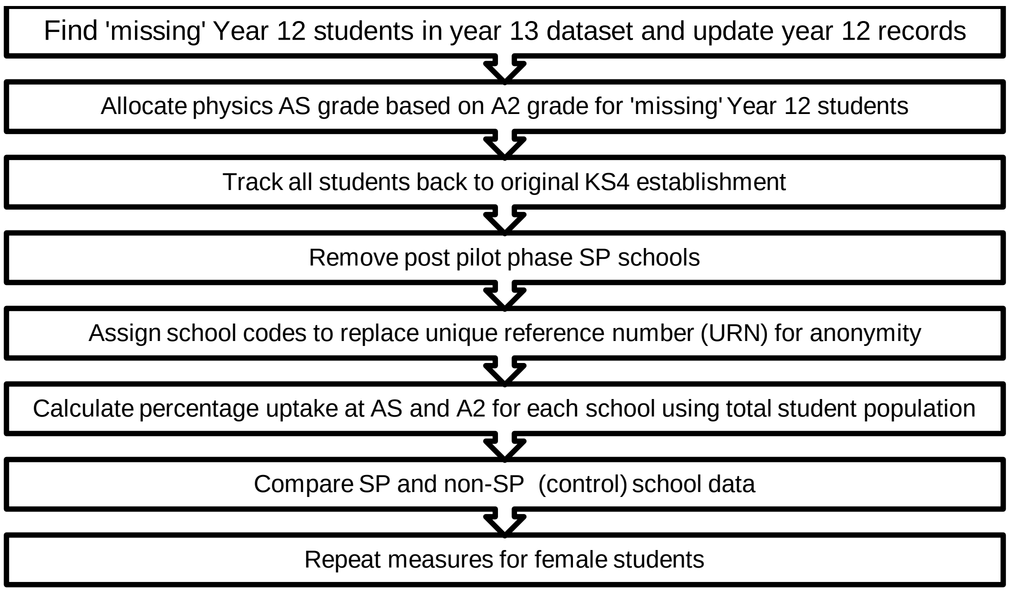

Figure 4.1: Data handling steps to extract relevant data for SP and control schools.

4.1.4 Tracking all students to their KS4 establishment

The number of students changing establishment at 16 is substantial. It was originally planned to track only 11-16 school students. However, after reviewing figures for 11-18 that had responded to the questionnaire and interview request, it became clear that 11-18 school students would also need to be tracked as the number transferring schools could mask any changes due the SP intervention. The Leeds Local Authority was used as a test and pupils tracked back to their KS4 establishments, with the following results (across years 2005/2006 to 2009/2010):

Table 4.2: Record of Year 12 students changing schools in Leeds' Local Authority across the longitudinal study

Leeds (LA 383) Total Year 12 in sample	15222
Number of Year 12 students remaining in same school as KS4	11294
Number of Year 12 students changing schools	3928
Percentage of Year 12 students changing schools	34.78%

In order to gain a more accurate measure, all students within the SP and control schools would need to be tracked. A combination of data handling programmes were used to filter the dataset and link pupil records between databases, i.e. SPSS, Access and Excel.

4.2 Quantitative Analysis of secondary data

Poor responses from school questionnaires led to a request for secondary data from the National Pupil Database to examine how student uptake of physics post-16 had changed in the pilot schools from 2005/2006 to 2009/2010. A comparison was made with the remaining schools in each region.

A benefit of using the NPD is that pupils from 11-16 schools can be followed through to their AS and A2 qualifications. The data that was extracted by the NPD required several processing steps to arrive at a sample that included the students' original school. I had written the code for tracking the 11-16 school students and also checked the destination data for pupils in 11-18 schools which revealed a large degree of migration in Leeds (34.8%). The focus of the Stimulating Physics pilot was at Key Stage 3 and Key Stage 4, therefore a more thorough analysis could be performed by tracing *all* Key Stage 5 students back to their Key Stage 4 establishment.

Many Year 12 students were missing from the data. By examining the Year 13 for subsequent years it was possible to add the missing students back into the relevant Year 12 cohort. I was able to track back missing Year12 students for all the academic years, with the exception of 2009/2010. Nottinghamshire seemed to have adopted a regional policy of not 'cashing-in' AS levels. The population in 2009/2010 was approximately 25% of that in 2008/2009. Therefore Nottinghamshire was excluded from the AS analysis.

4.2.1 Stimulating Physics (SP) school selection

There were a total of 24 schools from the Stimulating Physics pilot where the invention stopped in 2009. A new Regional Advisor for Oxfordshire was recruited at the end of the pilot and had continued to work with some of the schools beyond the pilot phase. These schools have also been excluded from the sample as they have been supported over a longer time frame than the other pilot schools. As a consequence, there are a lower number of schools from Oxfordshire in the data. There were nine schools from Leeds, nine schools from Nottinghamshire and six from Oxfordshire.

A specialist science college was recruited within each region to act as a hub for regional events and were also used to assist in the recruitment of additional 'spoke' schools within the region part way through the pilot. Any changes that had taken place in the spoke schools would be mismatched in this longitudinal study. The spoke schools were completed removed from the dataset as they were involved at a later stage. Each pupil was tracked back to their KS4 establishment and all 11-16 schools are included in the data. The statistics that follow are an analysis of the number of physics students *emanating* from each KS4 school rather than a simple count of the number sitting examinations within each KS5 establishment.

4.2.2 Analysis of AS data

School data for Year 12 AS students was amended to include any Year 13 students from the subsequent academic year that are missing from the relevant Year 12 cohort. However, the amendment cannot be made for the 2009/2010 academic year as the Year 13 data has not been submitted and there is a substantial shortfall in the Year 12 population for 2009/2010. In particular, there appears to have been a region wide policy in Nottinghamshire with regard to cashing in AS level qualifications and all the SP schools in Nottinghamshire were missing most of the data for Year 12 for this period. Therefore the analysis of AS uptake data through to 2009/2010 was limited to schools in Leeds and Oxfordshire. Relevant data for Nottinghamshire was treated separately.

Data was manipulated in order to perform an independent sample t-test for the SP and control schools. The change in the proportion of students taking AS physics in Year 12 was calculated for each individual school in the SP and control groups from 2005/2006 to 2009/2010.

From 2005/2006 to 2009/2010 there was a statistically significant difference between the change in uptake for SP and control schools in Leeds and Oxfordshire ($t = 2.75$, $df = 116$, $p = 0.007$). Figure 4.2 shows the mean change in percentage uptake of physics at AS level for each group. For SP schools ($n=15$, $SD=13.00$) the mean was 7.69% compared to 0.79% for the control schools ($n=103$, $SD=8.41$).

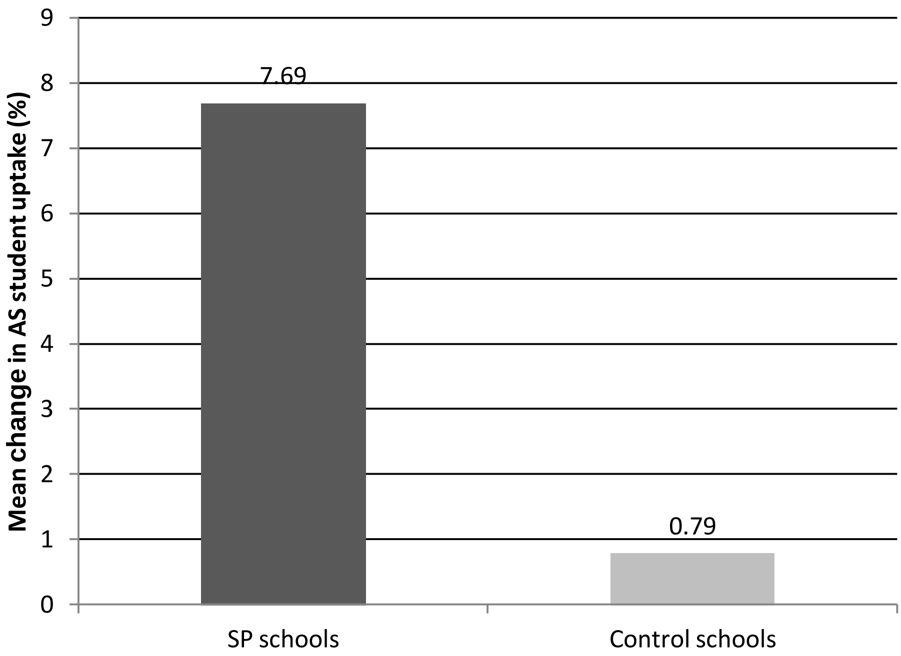

Figure 4.2: Mean increase in the proportion of the Year 12 cohort taking AS physics from 2005/2006 to 2009/2010 in Stimulating Physics (SP) and control schools

The results of an independent samples t-test for the Nottinghamshire region are not significant ($t = -0.217$, $df = 88$, $p>0.05$). This is unsurprising due to the low numbers of students present in the 2009/2010 Year 12 data set for the region.

Figure 4.3 shows how the uptake of physics at AS varied over the period from 2005/2006 to 2009/2010. Before the SP intervention the average uptake in SP schools in Leeds and Oxfordshire was 5.9%, compared to 6.3% in the control school sample. The SP schools showed an increase to 13.1% at the end of 2009/2010 compared with 10.8% in non-pilot schools.

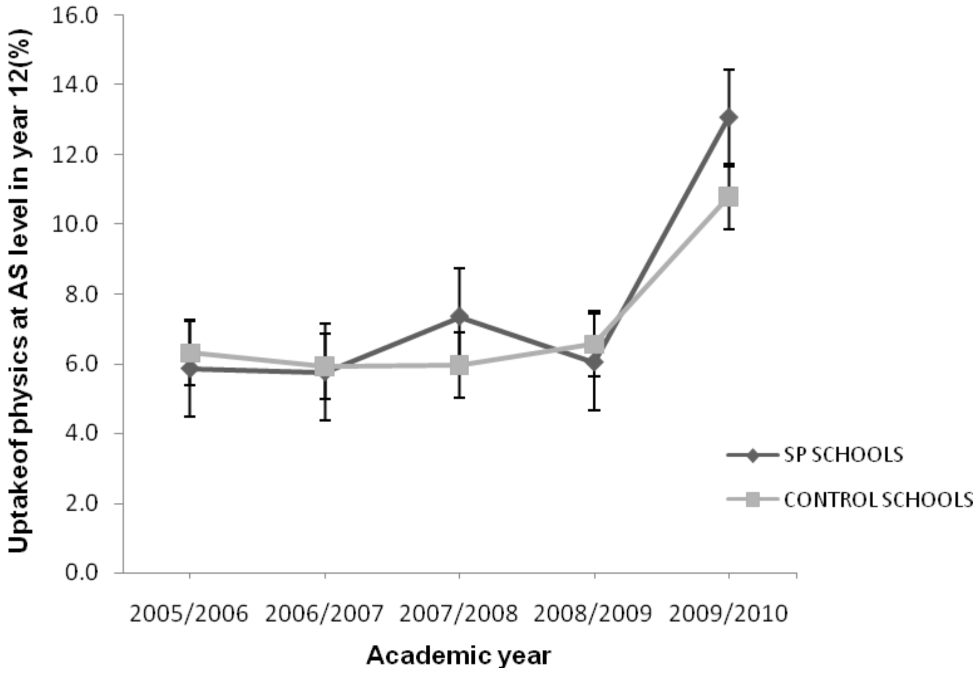

Figure 4.3: Variation in percentage uptake of AS physics in Year 12 for Leeds and Oxfordshire

The largest decrease in uptake was in school H, from 7.7% to 5.2% (10 to 5 students). The largest increases were seen in school W, where the uptake rose from 0.0% to 24.6% (0 to 17 students); in school G student numbers increased from 1.6% to 20.7% (1 to 18 students) and school D, where there was an increase from 0.0% to 13.3% (0 to 3 students).

Table 4.3 contains a breakdown of the uptake figures for all three regions. It should be noted that the data for Nottinghamshire contains the whole cohort of schools, but does not include figures for 2009/2010 due to the shortfall discussed earlier. In Nottinghamshire by 2008/2009, student uptake in the control schools decreased by 0.9% compared to an increase of 1.6% in SP schools.

Table 4.3: Proportion of Year 12 AS physics' students in Stimulating Physics (SP) and control schools across the three SP regions.

Region	2005/2006 (%)	2006/2007 (%)	2007/2008 (%)	2008/2009 (%)	2009/2010 (%)	Change in uptake 2006-2009	2006-2010
SP schools*	5.9	5.8	7.4	6.0	13.1	0.1	6.2
Control Schools*	6.3	5.9	6.0	6.6	10.8	0.3	4.5
Leeds (SP)	8.0	6.9	8.3	7.4	11.5	-0.6	3.5
Leeds (control)	9.5	7.8	8.2	8.6	9.9	-0.9	0.4
Oxon. (SP)	11.3	12.7	17.6	12.7	21.8	1.4	10.5
Oxon.(control)	12.4	12.4	12.4	14.3	18.3	1.9	5.9
Notts. (SP)	8.6	9.3	7.0	10.2	**	1.6	**
Notts. (control)	9.5	7.8	8.2	8.6	**	-0.9	**

*data combined from Leeds and Oxfordshire.
**There were a large number of Year 12 students missing in Nottinghamshire from 2009/2010, the population was approximately 25% of the preceding year.

The most dramatic increase for SP schools takes place in 2009/2010, which represents the cohort in Year 10 during 2007/2008 when several pupil-based interventions took place and teacher CPD had become established.

4.2.3 Changes in the uptake of female students at AS level

Part of the SP project was to improve the uptake of female students in physics post-16 and interventions ranged from careers events, teacher CPD, school trips and involvement in the IOP's Girls in Physics action research. Figures 4.4 and 4.5 show how the number of female students had changed from 2005/06 to 2009/10. There is a noticeable increase in 2008/2009 for the control schools, perhaps due to the introduction of GCSE 21st Century Science in 2006 (Millar, 2010). The control school numbers dip considerably in the following year, this is due to the missing student records from Year 12. The same decline should also be apparent in the SP schools, as there are the same systematic errors with recording the data. However, this is not the case and in the SP schools the overall number of female students increases by 38.9%

compared to a decrease of 9.7% in the control schools.

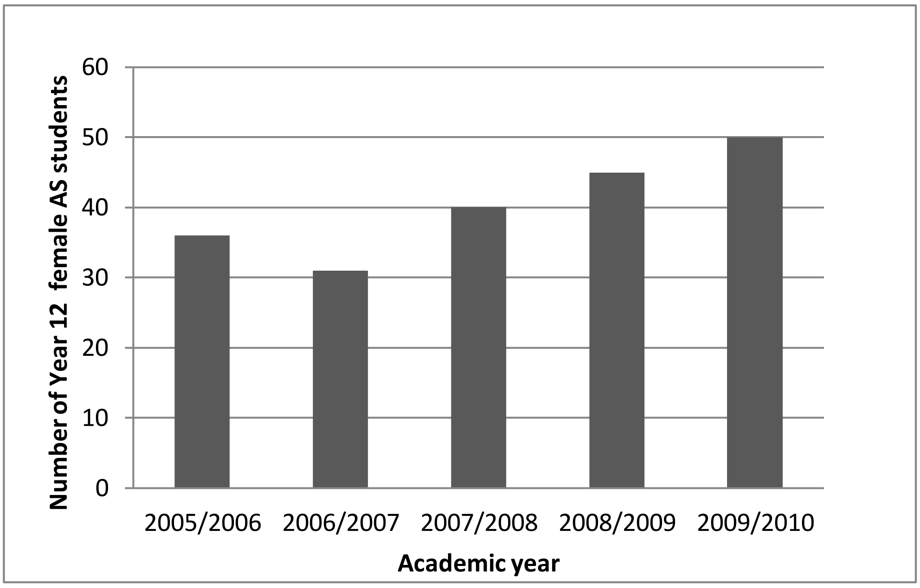

Figure 4.4: Number of female Year 12 AS physics students in SP schools.

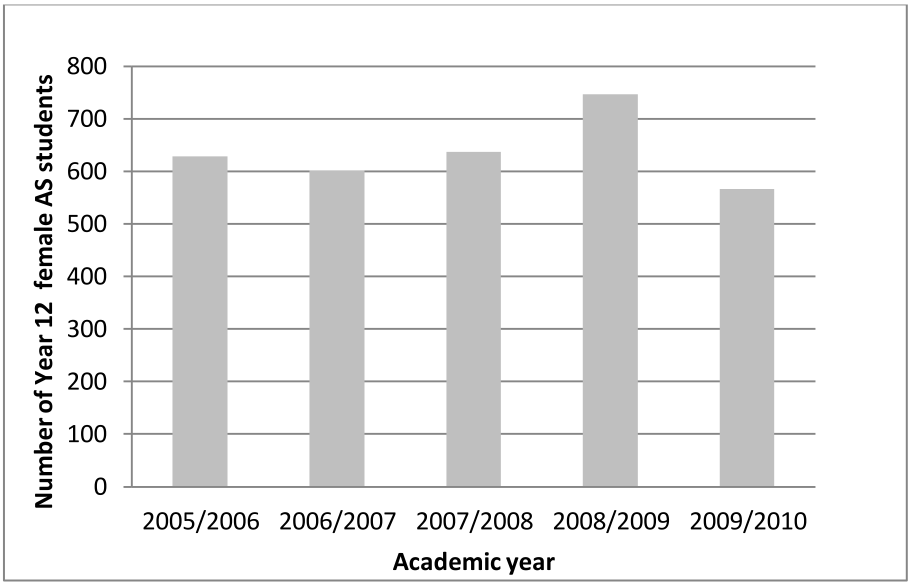

Figure 4.5: Number of female Year 12 AS physics students in control schools.

Table 4.4 contains the percentage uptake of AS physics for female Year 12 students. Data was combined from Leeds and Oxfordshire to form the totals for SP and control schools, as in the previous analysis for all students. The uptake of female students increased from 4.3% to 7.3% for SP schools and from 7.8% to 12.1% in control schools, a change of 3.2% and 4.3% respectively. SP schools had a much lower starting point than the control schools. However, these results were not statistically significant ($p>0.05$), partly due to the small number of girls opting for physics, for example, the actual number of girls in Leeds SP schools increased from 13 to 23 students.

Table 4.4: Proportion of Year 12 *female* AS physics' students in Stimulating Physics (SP) and control schools across the three SP regions.

Region	2005/2006 (%)	2006/2007 (%)	2007/2008 (%)	2008/2009 (%)	2009/2010 (%)	Change in uptake 2006-2009	2006-2010
SP schools	4.3	3.7	4.6	4.7	7.5	0.4	3.2
Control schools	7.8	7.3	7.4	8.1	12.1	0.3	4.3
Leeds (SP)*	2.7	1.6	2.7	1.6	5.7	-1.1	3.0
Leeds (control)	9.5	7.8	8.2	8.6	9.9	-0.9	0.4
Oxon.(SP)	6.5	6.6	7.7	9.2	10.1	2.7	3.6
Oxon.(control)	12.4	12.4	12.4	14.3	18.3	1.9	5.9
Notts. (SP)	3.1	4.9	2.6	5.2	*	2.1	*
Notts. (control)	3.7	4.0	4.7	4.5	*	0.8	*

*Nottinghamshire figures are missing Year 12 records for 2009/2010.

Data for Nottingham through to 2010 was less reliable due to the missing student records for Year 12, there were only 132 female students in the NPD data for 2009/2010, compared to 516 in the preceding year. From the 2008/2009 data there was an increase in uptake in SP schools of 2.1% compared to 0.8% in the control schools. The student uptake in Nottinghamshire seems to fluctuate more than in the other two regions, due in part to the low numbers in the sample (15 girls opting for AS physics in 2005/2006). In Oxfordshire the female student numbers have increased by 3.6% in SP schools and 5.9% in control schools, less of a contrast than in the other two regions.

Overall, the largest decrease occurred in school V (-4.2%) where students dipped from 5 to 3 students. Schools where the largest increases in uptake occurred were +16.3% in school D (0 to 2 students) and +14.3% in school G (0 to 7 students).

There has been a change in the uptake of girls at AS level from 4.3% to 7.5%. This may be a conservative figure as there are approximately 75% of the Nottinghamshire female students missing from 2009/2010. Fortunately, there will be a change in the 'cashing in' policy in future and any follow up analyses should provide more reliable data for AS students. School G had focussed support from the UKRC and participated in 'girls in physics' activities, including a careers' event with female role models and 'girls in physics' teacher CPD. School D also participated in 'girls in physics' CPD day. The Head of Department at school D stated that they were only able to offer GCSE physics in addition to Double Award science as a result of the non-specialist teacher CPD.

4.3 Analysis of A2 secondary data

From 2005/2006 to 2009/2010 there was a statistically significant difference between the change in A2 uptake for SP and control schools in all three regions (t = 2.11, df = 207, p=0.036). Figure 4.6 shows the mean change in the proportion of the Year 13 cohort taking A2 physics. For SP schools (n=24, SD=20.78), there was an *increase* of 4.35% compared to a *decrease* of 0.86% for the control schools (n=185, SD=9.57). There is less of an impact on A2 level than at AS level. These figures are a year on from AS and therefore further removed from the point of exposure to Stimulating Physics. There would have been less exposure to SP activities and new teaching practices that may have been adopted by their teachers.

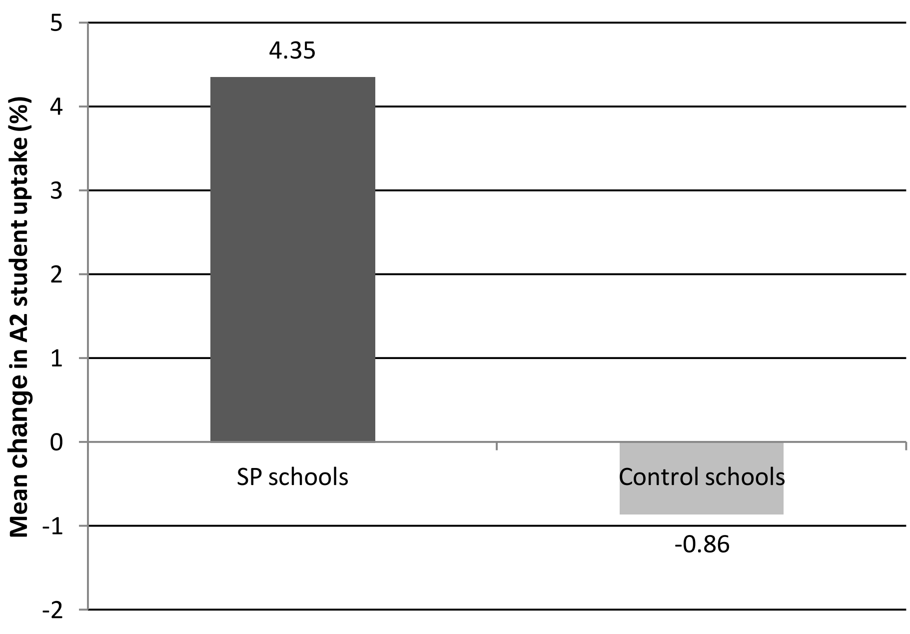

Figure 4.6: The mean increase in the proportion of the Year 13 cohort taking A2 physics from 2005/2006 to 2009/2010 in Stimulating Physics (SP) and control schools.

Table 4.5: Proportion of Year 13 A2 physics' students in Stimulating Physics (SP) and control schools.

Region	2005/2006 (%)	2006/2007 (%)	2007/2008 (%)	2008/2009 (%)	2009/2010 (%)	Change in uptake 2006-2010
SP schools	6.4	6.6	6.5	6.8	6.3	-0.1
Control schools	8.7	8.5	8.0	7.7	8.0	-0.7
Leeds (SP)*	5.1	5.7	4.7	4.3	4.6	-0.5
Leeds (control)	6.7	7.4	5.8	5.8	6.2	-0.6
Notts. (SP)	6.1	5.9	5.9	5.3	5.8	-0.3
Notts. (control)	8.8	8.1	7.6	7.6	7.8	-0.9
Oxon.(SP)	8.6	8.9	10.3	13.5	9.9	1.3
Oxon.(control)	10.5	10.2	10.5	9.5	10.0	-0.5

Table 4.5 contains the student uptake figures for A2 in all three regions for both Stimulating Physics and control schools. The 2005/2006 AS level *uptake* figures for SP and control schools were within 0.4% of each other for Leeds and Oxfordshire combined. The starting point for A2 uptake is 2.3% lower for the SP schools and this is the trend across all three regions. It is not solely due to the inclusion of the Nottinghamshire region in the data. There is a positive change in overall uptake in the Oxfordshire SP schools of 1.3%, compared to a decrease of 0.5% in the control schools. Overall there is little change in the *uptake* figures, although the actual *numbers* of students have increased over the time span.

The original aim of the demand strand of Stimulating Physics was to increase the numbers of students taking A level physics by 30%. Figure 4.7 shows how the student numbers have varied compared to the starting figures of 2005/06; both groups show a substantial increase over time and there is an encouraging upward trend. The overall percentage increase for Stimulating Physics schools is 55.8%, which is 25.8% above the original target. Of course, both groups have been subject to the influence of a the implementation of 21st Century Science (Millar, 2010) and the 'Brian Cox effect' (Vasagar, 2011).

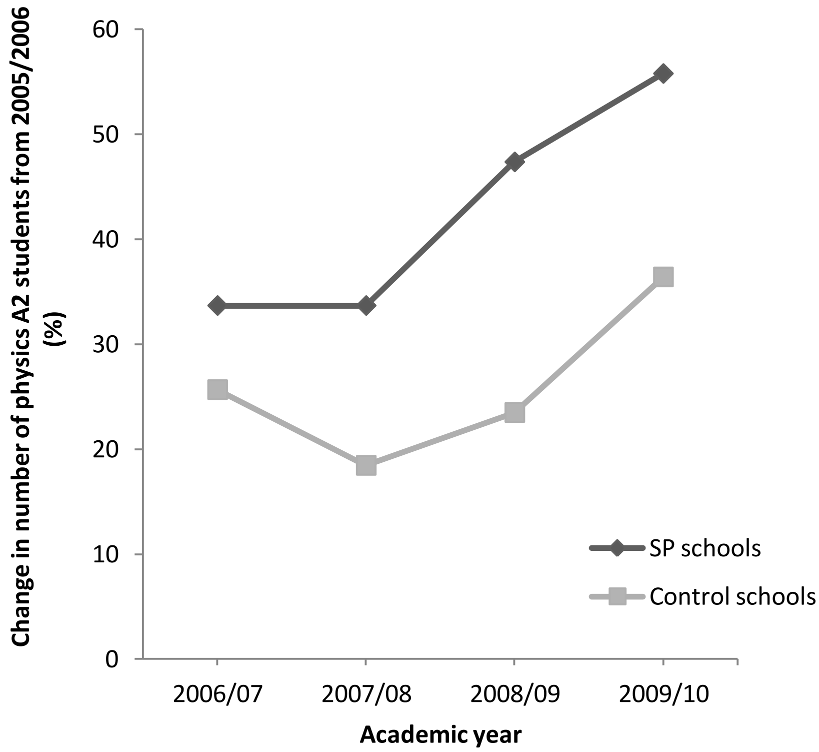

Figure 4.7: The percentage change in the number of Year 13 physics students at A2 level compared to 2005/06 in Stimulating Physics (SP) schools and control schools.

Gender

The actual number of female A2 physics students increased by 36.0% in SP compared to 16.7% for the control schools from 2005/2006 to 2009/2010. Analysis of percentage uptake data indicates a decline in uptake for both groups, however this is less marked for SP (2.9% to 2.6%) than in the control schools (7.9 to 6.7%). Of particular note is that in the Nottinghamshire region the number of female students had increased from 1 to 10 students during this time period.

4.3 Summary of quantitative data findings

1. Analysis of secondary data from the National Pupil Database supports the hypothesis that involvement in Stimulating Physics led to an increase in percentage *uptake* of physics post-16. The original aim of the demand strand of Stimulating Physics was to increase the numbers of students taking A level physics by 30%. The overall percentage increase for Stimulating Physics schools is 55.8%, which is 25.8% above the original target. There was an increase of 34.6% in control schools. Analysis of individual school uptake at A2 level revealed a statistically significant difference (p=0.036) between the change in student uptake in Year 13 where the mean change was an *increase* of 4.4% in SP schools and a *decrease* of 0.9% in the control schools.
2. Comparison of the proportion of Year 12 students pursuing physics at AS showed an increase from 5.9% to 13.1% in SP schools compared to an increase from 6.3% to 10.8% in control schools from 2005/2006 and 2009/2010. On an individual school basis, the mean change for SP was 7.7% compared to 0.8% for the control schools.
3. The largest increase in uptake was seen in Oxfordshire where student uptake increased from 11.3% to 21.8% in the pilot schools, compared with 12.4% to 18.3% in control schools. Oxfordshire had larger uptake at the start of the pilot and schools had participated in a larger number of industrial trust visits compared to the other two regions.
4. The dataset was incomplete for Year 12 students, notably in Nottinghamshire, where there seems to have been a Local Authority wide trend not to 'cash in' AS qualifications. As a consequence, the Nottinghamshire data was excluded

from the overall analysis through to 2010. However, student uptake had increased by the 2008/2009 academic year to a small degree.

5. With regard to female students, the percentage *uptake* at AS level had risen from 4.3% to 7.3% for SP schools and from 7.8% to 12.1% in control schools, a change of 3.2% and 4.3% respectively. These changes were not statistically significant ($p>0.05$), however this may be a reflection of the small number of girls within the dataset. In terms of actual numbers of female students there was an increase of 38.9% on baseline figures for 2005/06 for SP schools, but decrease 9.7% in control schools. Both groups of figures for 2009/10 would have been depressed due to unrecorded Year 12 data. The largest increases were seen in the Leeds' region which had focussed support from the UKRC, a partner in the Stimulating Physics programme that had provided 'girls in physics' training days and organised careers-based events with role models for Year 10 students.

5 Student interviews

The aim of Stimulating Physics was to encourage more students to opt for physics and also to ‘create a culture of physics’ in schools where perhaps this had been lost. The findings from the National Pupil Database (NPD) suggest that the level of impact varies dramatically from one school to another. Student focus group interviews were conducted in three schools where physics numbers had either declined, remained relatively static or shown an increase. Discussions with current Year 12 students were used to explore the reasons behind their choice to study physics further and to identify any effects that may have been due to Stimulating Physics activity within the school. This chapter focuses on what led students to opt for physics, evidence of Stimulating Physics initiatives, gender differences and students’ ideas on encouraging younger learners to pursue physics.

5.1 School profiles – NPD data

Student focus group interviews were arranged during the summer term after examinations had taken place. Three schools were chosen, on the basis of replies to the initial questionnaire, National Pupil Database (NPD) analysis and their availability (see Table 5.1 and Table 5.2 for student uptake figures at AS and A2 respectively).

Table 5.1: Number of AS physics students for each school interviewed.

	2005/2006		2006/2007		2007/2008		2008/2009		2009/2010	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
School A	4*	1*	7	1	10	1	7	1	6	3
School B	5	1	1	0	12	2	11	5	11	1
School C	21	4	10	1	18	3	16**	3**	24**	1**

* data missing from NPD, inferred from A2 figures for subsequent year.
** data from school survey as students missing from NPD as AS levels weren’t ‘cashed in’ that year.

Table 5.2: Number of A2 physics students for each school interviewed.

	2005/2006		2006/2007		2007/2008		2008/2009		2009/2010	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
School A	9	0	3	1	5	1	6	0	7	1
School B	2	2	5	0	2	0	7	0	9	0
School C	6	3	12	2	7	1	11	1	7	1

Within each school it was requested that students were randomly selected by the teacher. Groups were arranged so that an equal number of boys and girls were present or there was a single-sex group. Drever and Munn (2004) suggest that that numbers of each gender are balanced in a mixed focus group to help ensure more balanced contributions. It had been observed in a trial focus group where there was one girl present that the discussion was dominated by the male members of the group.

The appointment was made with the school several weeks in advance. However, the contact teacher was unaware of a clash with University open days in school A and here only three students were available. There were a total of five focus group interviews: two groups of boys; one group of girls and two mixed groups. There were a total of 16 physics' students interviewed, 6 girls and 10 boys. In addition, there was one girl in the all girl group who had not opted for physics, but made some interesting contributions to the interview discussion, so her comments have been included in the results section. The students were assigned a code which included their school (A, B or C), followed by gender (B or G) and a student number for each school. For example, student AB1 was a male student from school A, whereas CG3 was a female student at school C.

5.2 Patterns of subject choice

Although this is a small sample, it is interesting to note that there is greater take-up of the three traditional sciences in the science specialist school, C. Of the 8 physics students interviewed 3 boys had opted for physics and chemistry, and 3 girls had taken all three sciences. The specialist status was mentioned by two of the boys at school C as being a positive influence on their decision to do science: 'if you do a science….you're going to do quite well in it' (CB4) and 'you're going to have all the right facilities (CB3).' There were no other students who had taken all 3 sciences in the two other schools. There were only 3 students available for interview in school A; here they had each chosen only one other traditional science subject with physics.

Table 5.3: Student interviewee AS subject choices (Russell Group 'facilitating subjects' in red).

Student	Physics	Biology	Chemistry	Maths	Art	Business Studies	Computing	Drama	Economics	English Lang	Further Maths	Geography	History	IT	Music technology	Physical Education	Psychology
AG1	A2		AS	A2													A2
AB2	A2	A2		A2												AS	
AB3	A2	AS		A2								A2					
BG1	A2			A2	A2										A2		
BB2	A2			A2						AS			A2				
BB3	A2			AS		A2		A2									
BB4	A2			A2	A2									A2			
BB5	A2			AS	A2									A2			
CG1	A2			A2					A2		AS						
CG2	AS	A2	A2							A2							
CG3	AS	A2	A2	A2													
CG4	A2	A2	A2	A2													
CG5*		A2		A2	A2												AS
CB1	A2		A2	A2							AS		A2				
CB2	A2		A2	A2							A2						
CB3	A2			A2			A2			AS							
CB4	A2		A2	A2									AS				

In school B none of the 5 students interviewed were taking another science with physics, and three of them had the unusual combination of art. This appears to reflect the observation that careers advisors suggest a broader spread of subjects in order to ‘keep options open’, where the student is unclear on which subjects to opt for (Bennett et al, 2011). All the students at school B mention speaking to Connexions. It would appear that the school B’s involvement with Stimulating Physics has resulted in these students selecting physics in preference to biology, which is the preferred option for those students pursuing just one science at AS level. If students are to be better prepared for university, then it would seem sensible to promote the ‘facilitating subjects’ as identified by the Russell Group (2011) which lists physics as the second most ‘facilitating subject’.

Fifteen of the sixteen interviewees were taking mathematics courses. Of the sixteen, two girls (both at school C) are dropping physics, CG2 did not take maths at AS level and cited a lack of confidence in maths, and the other, CG3, felt that her maths statistics course did little to support her mathematical reasoning in physics.

5.2.1 What led the students to opt for physics post 16?

There is often a combination of factors that influence students when making decisions regarding subject choice (Bennett et al., 2011; Osborne et al., 2003).

I asked the students if they could recall discussions about their AS choices and at what stage they had decided to take physics further. During the five focus group interviews the following factors were discussed by the students as playing a significant role:

- Family
- Teachers
- Subject interest
- Career plans

5.3 Family

The influence of family has been identified by several studies as having an important role in students' subject choices (Krogh & Thomsen, 2005; Maltese & Tai, 2010). Discussions were parents were mentioned by nine of the sixteen physics students interviewed, for example, 'I spoke to my parents about it, as I always would as it's quite a big decision' (CB3). However the level of discussion varied from students informing parents of what they had already decided to do, through to parents' having a dominant role in the decision making.

> CG4: as for what I wanted to do I just spoke to my parents about that. There weren't really many people to talk to in school.

A few students acknowledged that their parents had a more pivotal role in their subject choice and that the influence extended beyond discussions regarding post-16 study.

> CB2: He's a GP so I suppose he did three sciences and so I mean I got to be interested in that sort of thing. It's bound to have had an influence on me.

Others felt that any discussion was a confirmation of prior expectations

> CB2: They kinda expected me to do maths and science so when I spoke about it they said well if it's what you want to do, then that's fine.

Some self-motivated students 'told' people what they wanted to take: 'I just told my mum really' (AB3) or were completely independent in the decision making. This strength of commitment had developed over the preceding years. Students also spoke of a love of physics that had been nurtured at GCSE.

5.4 Teachers

More often than not, subject teachers were consulted by the students to confirm if they were capable of meeting the demands of the course. The students' experience at

GCSE and advice from the subject teachers emerged as the most common influences on their decision to take physics further.

> CG4 I discussed with my subject teachers whether they thought I'd be able to keep up with the courses,
>
> BG1: I've just always loved it, every lesson I sat there and took in everything that they said. If I was going to choose a science, physics was the one that I got the highest grades and it's a lot more enjoyable.

Three students mentioned that their results had been a factor in deciding to continue with science post-16. AG1 remarked that she had performed better in physics than biology and this was why she had taken physics.

In order to do physics the students felt that pupils needed to know what the subject was and that its identity was much clearer once they had started studying triple award science. They felt that having a specialist teacher was of considerable benefit.

5.5 Subject interest

As part of their involvement with SP, students from school B had visited a space centre with the industrial trust, of the sixteen students interviewed four boys from this school mentioned an interest in space as a reason for taking physics, for example student BB2 responded: 'one subject that has always interested me is space and astronomy. About the solar system….that's why I've always liked physics.' This may be partly linked to the schools' visit to the space centre, although for some of the boys 'space' seemed to have been a personal interest for several years.

Most students discussed outside interest in physics and this ranged from watching TV programmes, books on quantum mechanics, visiting museums. Two of the students from school B had been to a 'Bang goes the theory' road show and a recording of the

‘Infinite Monkey Cage’ for Radio 4 where they had queued to meet Professor Brain Cox and have a book signed. Professor Cox’s TV programme, ‘Wonders of the Universe’ had been avidly viewed by some of the students. One student, AB3, remarked ‘if you just saw him walking the street you wouldn’t think ‘oh he’s got a PhD in particle physics’’; he thought that the programme had helped subvert the stereotype that physicists work in a laboratory in a white coat. The ‘Brian Cox effect’ has been acknowledged as having a positive effect on physics uptake at A level (Vasagar, 2011).

5.6 Career plans and advice

The majority of the students interviewed were clear about university courses they would apply for or in the case of three of the six girls opting for physics at AS, had a clear profession in mind. Three students had ‘no idea’ of what they wanted to do next, and these were all male students.

Despite more input from Connexions, students in school B were less decided on their next step. Only one student (BB2) had a clear idea on a career – primary school teaching.

There seems to be an ethos amongst the physicists at school A to pursue physics beyond their A level courses: ‘I was thinking of doing physics in either Birmingham or Manchester and Edinburgh as well. Hopefully I can earn lots of money from it, that’s my plan.’ (AB2). The fact that physics courses are harder to get onto was an indication of higher earning potential for student AB2. Student AG1 thought that the majority of the ten students at school A wanted to do something around physics or take it further. Another student at the school had considered applying for physics at

Manchester but had decided to pursue Geophysics instead as the required grades of an A* and 2As were too high. I asked this student why he had picked Manchester?

> AB3: Because of reputation mainly. I know Brian Cox [A popular presenter of physics programmes on the T.V.] is at Manchester.

In school C, three of the four female students had all made a decision prior to their AS courses and were interested in careers in civil engineering; marine biology and medicine. Of the male students one had a clear plan to study maths, two others thought chemistry and one was undecided. There was a difference in careers' focus between the girls and boys interviewed: the girls had much clearer ideas about what profession they would like to enter as a result of their qualifications.

Careers advice

What has emerged from the interviews is that in two of the schools there was no clear careers' advice structure and/or students are not fully aware of where to look for advice or the career paths that are open to them by studying a physics degree.

It would appear that there was a clear structure of careers' interviews at school B, although advice was conflicting for two of the students, student BG1 thought that 'they were a bit worried' about her taking art at A level, whereas student BB3 was advised to take art A level as it was one of his stronger subjects. Student BB3 did not 'see this as an option from a career point of view' and had used google to research career possibilities. The other schools' students mention careers advice as being sporadic and do not seem to have found the advice offered particularly useful in deciding on their AS courses, for example: 'the careers interviews weren't particularly helpful because they didn't guide you where you wanted to go. They were just a general 'what do you think at the moment?'' (CG4).

Student comments seem to echo the recent research into the role of careers advisors in schools: “major changes in the aims of Connexions will need to be made if it is going to help in the selection of academic AS subjects, including P/C AS subjects” (Bennett et al., 2011, p.50). It would appear that careers advice from Connexions has not focussed on the most suitable combination of subjects for pursuit of sciences at University level. Many students feel careers interviews are for those who already have a specific career in mind. Perhaps ‘careers’ is a misnomer and leads to a focus on the vocational rather that the academic route open to students.

5.6.1 Gender differences

Several of the boys classified themselves as ‘visual learners’ and mentioned using diagrams to aid their understanding. They also had more of a leaning towards practical work: ‘I’d probably fit in as many practicals as I could. I could try every lesson that way it could be more fun’(BB5). Whereas the girls needed to have a clear objective before starting a practical activity: ‘sometimes we do an experiment without really knowing what we’re doing it for’ (CG4). In school B, student BG1 thought that a good lesson would include a practical activity that prompted you to ‘think about why something might happen’.

It is of interest that of the six girls interviewed three of them mentioned their mothers having a role in their decision making and having a scientific/mathematical bent, which accords with research findings on the significance of mother-daughter interactions when girls pursue science (Bhanot & Jovanovic, 2009; Tenenbaum, 2009). None of the ten boys mentioned their mothers having such a role.

> BG1: My Mum was always keen on maths, and I think that when you speak to her she’s got the sort of physics brain like ‘how does that work?’ why is it like that, but she never took it past GCSE.

This student spoke with enthusiasm about her physics studies and her own interest outside school.

In the girl only focus group there was a discussion surrounding their perceived gender differences in the approach to studying physics:

> CG2: I think boys and girls are really different, the boys in our class will literally go through calculations on a calculator and that would be that, whereas if I don't write the whole equation down, everything, with examples, I don't have a clue when it comes to revising.

This particular discussion turned to the effect of the media, students mentioned the image of a physicist working in lab coat and the 'Big Bang Theory' TV show: 'It's made out to be really geeky' (CG1). They thought that the media did little to encourage girls to study physics and that it was depicted as a male subject.

Self efficacy in their mathematical abilities was an issue for the female students:

> CG2: It's not the theory I don't understand, it's doing the calculations.

Maths' ability was also mentioned by a student at school B, who seemed to be very capable and had discussed with enthusiasm how the more challenging physics topics appealed to her:

> BG1: I need a good explanation mathematically, that's something I've always had trouble with. I need plenty of examples cos I don't really get it unless I've done something ten times.

One of the girls thought that it would be particularly useful to speak to current students about how they were coping with the mathematical challenges 'because the teachers obviously have a good grasp of maths so they might think that you can get away without doing maths' (CG4). This collection of comments by the girls echoes the research of Bennett and Hogarth (2009) where boys were ten times more likely than girls to highlight liking the maths in physics. The boy only group in school B had mentioned that they did not like the calculations, and that they would prefer to learn more ‘visually’ (BB3). However, the emphasis was on the lesson content rather than their perception of their own abilities.

5.6.2 How can we encourage more students to do physics?

As the students had already participated in some of the activities developed by Stimulating Physics and may have been taught using pedagogical content knowledge developed in the teachers’ CPD, I was keen to explore how and when they thought physics could best be promoted to younger students.

In the main, male students thought that any intervention should take place early on, either at primary school or pre- GCSE:

> BB2: I think if you speak to younger students, perhaps end of primary or end of Year 7. If you could demonstrate how good physics can be and how useful in everyday life and make them able to look at all what it’s done for us.

Conversely, the girls all thought that any physics-based intervention should take place at Year 10 or Year 11 and thought that Year 7 students’ understanding would be limited as ‘you’re just interested in blowing things up and playing with the Bunsen burners’ (CG1). This was put in a more positively by student at school B:

> BG1: When I started taking my GCSEs I wanted to be a fashion designer and now I want to take physics further, so you can change.

Most students were in agreement that giving physics a clear identity lower down the school would help to get more pupils engaged with physics and that this hinged on having a specialist or knowledgeable subject teacher. This sentiment was embodied by student CB3: ‘make them aware that they’re actually doing physics, instead of just having a broad science lesson.’ The point is reinforced by the students’ comments regarding what they thought made a good physics lesson. Students thought that a good lesson needed to be explained clearly (BB1), ‘bringing it alive….it’s the little things that you notice in real life’ (CG4). Being able to talk around your subject and provide anecdotes is seen as a quality possessed by subject specialists that is lacking in other teachers (Kind, 2009; Murphy & Whitelegg, 2006).

Some of the students in school C reflected on the merits of having a physics specialist teach them. 'If the teacher has done it at university so they go into bits of detail that maybe are not on the course, but it's something they might find interesting' (CG4). One student thought that not having a physics specialist at Key Stage 3 would mean that 'you're not going to learn about it. They're not going to cover physics as much' (CB4). These statements were volunteered by the student and emerged out of the discussion. Although this particular point was not on my original schedule, it underpins the rationale behind the CPD support for non-specialist teachers at KS3 which was a core activity in Stimulating Physics programme.

5.7 Stimulating Physics – evidence from student interviews

5.7.1 Evidence of CPD in teaching

The students in schools A and C had been taught by specialist physics teachers during their GCSE course, but there was some evidence of Stimulating Physics having an effect on them. In school B they had been taught by non-specialists and here there was evidence of the subject specific CPD impacting on classroom practice.

About half way through the interview the researcher used an orange-coloured smoothie and cups to model energy 'shifting' (as advocated in the IOP's Supporting Physics Teaching materials), the approach to teaching Energy is novel and can be unsettling for some teachers. It is therefore a strong indicator that the school had fully embraced the teaching support:

> BB4: is that like energy being transferred, like transferring energy from one object to another….the fluid is energy the cups are the objects.

However, in school C, it was exposure to careers information at a conference that had filtered down to the students.

> CG2: I remember CT1 showing us a slide of the highest paid jobs for equivalent degrees and if somebody shows you that in Year 11 then I think it would change your mind.

Teacher CT1 had attended a SP teachers' conference in July 2008 and was sent a copy of the powerpoint of the presentation regarding physics careers, which included a graph of future earnings based on degree subject.

5.7.2 Girls in Physics activities

The female students in school C volunteered information regarding a 'Girls in Physics' SP event in response to a question regarding whether they had met a physicist. It was a half day activity which had included interviews with female role models from Astrophysics, Biomechanics and Civil Engineering. The student responses were mixed: 'they talked about their jobs in physics and they all sounded really good' (CG5); 'maybe it was a bit wasted on some people' (CG4).

In school B, female students had been taken on a 'girls only' trip to a local recording studio in Year 10. 'It was a good trip, but it wasn't really physics related…I remember thinking that it would be one less girl for physics. Then I must have changed thoughts somehow'(BG1). This student has opted for Music Technology A level. She attributes her choice of physics as being due to 'the actual lessons' and noted that they did not become 'really interesting' until Year 11. The responses indicate that careful selection of role models and activities is required and that by Year ten the female interviewees may have become rather cynical.

In school B, the trip to the space centre with the industrial trust was organized for the two top sets of Year 10 students from school. ‘It helped reinforce that I really liked physics and space, it was designed only for schools and not the general public.’(BB1).

Although some students enjoyed the visits arranged as part of Stimulating Physics, this was not universal and it would appear that visits to or by external parties have much less impact than the longer term relationship with the subject teachers. On occasion, a seed may have been sown.

5.8 Summary of student interview findings

The semi-structured interview format helped provide useful insight into how and when the pupils had made their choice to do AS level physics, ranging from a long-term interest in physics e.g. space topic cited by several boys to a last-minute change of plan due to personal choice or timetabling issues.

There were a range of factors behind subject choice: some students had clear career plans and had conducted independent research, some had an enduring interest in physics, whereas others relied heavily on parental opinion and advice from family friends. What emerged the interviews was lack of structured careers advice in some schools and pupils’ needs for clearer direction when choosing the appropriate subject combinations to support their learning in physics. The most common source of inspiration was their GCSE physics lessons and advice from subject teachers.

Girls seemed more concerned with their mathematical ability and most mentioned a need to practice and require several examples in order to feel confident, this area was not discussed by any of the boys. Another gender difference was that girls were more focused on a career path and used this to help make their AS choices.

Subject combinations have an effect on whether pupils continue with physics through to A2. Not taking maths at AS was regarded as an ill-advised decision. Pupils thought that discussions with current AS students when they were making their subject choices would have helped them understand the mathematical challenges of the course.

Girls in physics initiatives have had some impact; however, there were mixed responses which seemed to depend on pupils' pre-existing areas of interest. One pupil felt that not all role models were suitable. This would point to providing more opportunities for interaction with a larger range of role models throughout lower school and echoes findings of attitudes in science. The girls were inclined to be cynical about being targeted in an overt way. Perhaps a more subtle 'drip-feed' would be more effective.

What has emerged from the interview process is that an increase in group size has an understandable effect on the depth of response each individual is able to make. In a larger group, there will often be a more dominant contributor and care needs to be taken to ensure that quieter members of the group are able to make a balanced contribution to the discussion by the use of prompts and eye-contact (Drever, 2003).

The impact of Stimulating Physics was most evident in the school lacking specialist teachers of physics. In this school the pupils had direct experience of the Supporting Physics Teaching approaches advocated by Stimulating Physics. It is interesting to note that there was the greatest change in student numbers taking physics in this school. There had been minor changes in the other two schools.

Portrait of a physicist

A set of characteristics emerged from the interview process. A student who was interested in pursuing a physics career responds positively to the challenges of the course and feels 'smart'/intellectually rewarded by solving problems. They had a clear career plan, at least to University level. There was a demonstration of an outside interest in physics – independently reading, visiting science-based shows/museums. The student had received good advice from teachers when choosing AS subjects and was confident in their mathematical ability.

6 Teacher interviews

Teachers in four schools took part in a series of individual interviews and focus group discussions to determine if a Stimulating Physics legacy remained and if this had any link with increased uptake at AS level. Unfortunately none of the teachers involved in the Stimulating Physics pilot were still at school C, including the lead teacher so it was not possible to arrange an interview there.

The interview responses have been used to provide a case study of each school, the level of change varies between each of the four schools, as does the cross section of teachers interviewed. A case study approach provides a more cohesive account of any changes in each establishment as a result of the pilot.

6.1 School A – single interview with physics SP lead teacher

School A is an 11-18 school, in which student numbers taking AS physics had remained at around 10 (+/- 1) over the four years up to 2009/2010. However, the number of girls had increased from 1 each year to 3 in 2009/2010. There were 3 physics specialists out of a staff of 11 at the start of the pilot. This school had participated in all facets of the student-based activities, arranged regular CPD for non-specialists in school, but they had not attended the summer schools. The lead teacher was a physics specialist who arranged time to attend summer conferences at the IOP and participated in a one day careers event and a 'girls in physics' training day. Unfortunately, none of the five non-specialists who had participated in CPD had remained at school A. Two of the teachers had sought positions overseas, due to a lack of a permanent contract in the UK. Therefore, there was a one-to-one interview with the lead teacher (AT1) to discuss how he thought the Stimulating Physics invention had affected physics teaching and uptake in his school.

AT1 reflected that the teachers had felt the training gave them confidence to teach the topics covered and that as a group they had selected topics that were due to be taught in the same term. He noted that they had not collected any hard data to compare students before and after the training. He felt that there had been a lack of cross fertilisation and that although the non-specialist teachers had benefitted on an individual level, any newly-acquired knowledge had left with the teachers. Alternative teaching approaches had not been incorporated in the schemes of work; this was largely due to the fact that the physics teaching schemes were written and modified by the subject specialists. He acknowledged that there needed to be time in departmental meetings to share the SP approaches with the rest of the department and that he 'probably wasn't the right person, you need the person who makes all the final decisions. You've got to get them to buy into it'. There was an honest reflection that if student numbers in the school were comfortable, i.e. there was no risk of the course closing due to poor uptake, then an increase in student numbers could result in group sizes that were harder to manage, especially due to the practical requirements of the physics courses.

AT1 felt that direct contact with the head teacher by the regional advisor had been instrumental in allowing students to engage fully with the SP activities. School A students took part in a pilot for the Ashfield Music Festival, online networking and there were several Industrial Trust visits across Year 9 to Year 11. One of the trips had been for girls only and AT1 felt that there had been a much higher level of engagement amongst the girls than he had previously observed for mixed groups, where the boys tended to dominate.

Several times AT1 referred to the need to target a particular group of students. He asserted that ‘spreading it thin and having them do one thing that they might engage with is too risky’. He had selected pupils from top sets who were not interested in pursuing physics, although he had thought they were capable.

With regard to advising prospective physics students, AT1 said that he would encourage them to speak to existing students and provide links with current (GCSE) teaching. He observed that some state that they enjoy physics but that they do not rank it above other subjects. He mentioned that he had used a graph of future earnings for the sixth form open evening; this had been presented at the lead teachers’ summer conference in July 2007. A student from the interviews had made a point of the earning potential of physics (AB1) and how this had motivated him. AT1 thought that careers advice was limited and that it was up to the subject teachers to sell their subject. The focus of advice at GCSE was more on destination than subject choice and teacher AT1 thought that there was pressure on students to remain at school A for their sixth form studies. In conclusion, AT1 reflected that ‘there weren’t many footprints’ left by the SP pilot, though if given the opportunity he would be keen for the school to participate again with greater commitment from the science management team and over a longer time period.

6.2 School B – group interview with two science teachers

School B is also an 11-18 school, at the start of the pilot there was one physics specialist in a department of nine staff. However, the science department is currently without a specialist physics teacher. The lead teacher (BT1) at the start of the pilot was heavily involved in the girls in physics aspect of the pilot and had arranged girls-only events to help promote physics to Year 10 students. This seems to have borne fruit and the AS numbers for girls in particular showed a large increase for the 2008/2009 academic year. Teacher BT1 went on to complete the physics science additional specialism programme and is now working at another school teaching A level physics. She was therefore not available for interview.

Teachers from school B attended all three available summer schools, in different combinations, and had found this method of support more suited to their school's CPD structure. I spoke with two female teachers, both psychology graduates: one of whom (BT2) had completed a chemistry conversion course and had been teaching for five years; the other teacher (BT3), now head of department, had been teaching for 11 years and her main subject was biology. All the teachers in the school taught some physics up to GSCE.

BT2 and BT3 had participated in school CPD sessions and attended two summer schools each. BT2 said that she found the working environment of their school distracting, and preferred the focus afforded at the summer school. With the exception of one INSET day, the school's senior management team had not allocated time within its CPD programme for SP support. BT3 also mentioned Year 9 pupils' science engagement day with IOP staff had been planned, but this had been cancelled due to funding issues. Neither of the teachers was aware of particular girls in physics activities and there seems to have been a lack of communication in the department. Both teachers mentioned a lack of time to discuss curriculum changes and development: ‘we’re always rewriting the next scheme of work, we don’t have time to review them’ (BT3).

BT3 mentioned particular practical activities that she had tried with pupils and said that she felt they were more likely to remember things as a consequence. She also mentioned how she had practiced using the ‘rope loop’ model for electricity in a training session in a group of 3 or 4 teachers and adopted the same approach successfully with her Year 7 students later on in the term. Joyce and Showers (2002) refer to the need to rehearse in a realistic setting as part of the process of assimilating a new teaching method. BT3 was only able to make qualitative observations regarding her physics teacher, but felt that students were more engaged, this was reflected by the range of questions that they asked.

BT2 felt that she had improved confidence in teaching physics as a result of the Stimulating Physics pilot. She mentioned using the ‘force arrows circus’ and rope loop model and thought that the training had provided her with techniques that she ‘wouldn’t have had the creativity to invent’ for herself. She acknowledged that she sometimes had to give herself ‘a jolt’ to remember to use the resources that she had acquired through her SP training, particularly where there had been a long time lag between the training and teaching the topics.

BT3 reflected that it would be a good idea to put the activities into the new schemes of work that were about to be written so that everyone had access to the materials.

According to Guskey’s framework (Guskey, 2000) there is evidence of new pedagogy in the classroom, however there has been less organisational change within the whole department, due to a lack of commitment by the senior management team. A change in personnel could have put additional stress on the teachers working in the department and there has been difficulty in embedding novel approaches in the science schemes of work. It seemed that a lack of time and other school pressures had prevented a more ordered consolidation of what the teachers had gained from their SP training.

6.3 School D – group interview with three science teachers

School D is an 11-16 school, where there were no students taking physics post-16 in the year preceding the start of the pilot. At the end of 2009/2010, three students took AS level physics including two girls. These three students represent a 13.0% uptake, of a total population of 23 students that have continued into Year 12 in other establishments. A group interview was conducted with three members of the science department: the head of department (DT1); an experienced biology teacher (DT2); and the senior laboratory technician (DT3), who had also been working as a Higher Level Teaching Assistant for three years.

School D is a relatively small school; there were five teachers in the department at the start of the pilot, one of whom was physics specialist.

All the science teachers from the department had attended the first summer school, excepting their physics teacher. The three interviewees had found the summer school atmosphere conducive and mentioned being comfortable about asking questions and valued the opportunity to talk with ‘like-minded people’ (DT2).

There had been a regular programme of CPD in school, which was scheduled to fit into the school working day. In school D, the physics component of the GCSE science course is taught to all students simultaneously, to allow students to move between teaching groups if required. The CPD topics were selected to coincide with the time they were due to be taught, the GCSE content was relevant to the whole department's teaching sequence. For example, DT1 stated that 'the best thing about the training was that it was specific to their needs at the time'; as a consequence activities were incorporated into their teaching 'straight away' and that they 'had a chance to discuss as a team' how it would fit into their curriculum.

DT2 thought that it was the 'most valuable training' he had had in 30 years. He thought that it was a contrast to university courses where they show you experiments that are 'impossible to do' and that the instructors 'know the problems of working in a classroom, knowing you've got 20 kids who are completely disaffected and how you can get them engaged'. DT1 found discussions with fellow professionals who had already taught the topic in their school provided her with another layer of support.

DT3 noted that they had to set things up independently in the practical sessions and practice 'in front of your peers, which is sometimes harder.' This had helped her gain confidence in her ability to demonstrate the activity in school. DT3 thought that the 'hands-on' nature of the training had been a particular benefit. DT1 had appreciated 'clear practical advice on how to do it in the classroom, with kit that you already head'. DT1 admitted that she had previously avoided using the Van de Graaff generator because of safety concerns, she reflected that 'it was such a simple thing to hold a metre rule, but such a simple thing can make a massive difference'.

The teachers thought that there had been noticeable changes to their teaching as a result of the CPD:

> DT2: I use big circuits in electricity and now I do big demonstrations. I'm much more confident setting things up. I do balanced forces now with pulleys and get the kids to balance. It's an amalgamation of things I've seen.

This teacher had gained enough confidence to develop his own activities based on his experience of trialling new teaching approaches in the classroom. He also mentioned that he felt his lower-ability students found the activities more engaging.

DT3 specifically referred to using 'energy pathways' (SPT) in her teaching and that in her role as technician she was able to provide support to newer members of staff and show them alternatives from the SPT resources.

The head of department, DT1, mentioned that they 'talk and share resources on a folder' and that new resources go straight into the schemes of work. She felt that the biggest change in the classroom was 'instead of showing a video and giving a worksheet, you'd see a person who's interacting, asking questions, developing activities....I'm much more confident that I understand it and that I can deliver what the class needs'. DT1 was open and candid in front of her colleagues, and it was evident that she felt as much a part of the CPD as the rest of the department.

School D had participated in all of the pupil-based activities in the pilot, including some directed work with the UKRC on girls in physics. DT1 felt that the e-mentoring project had taken too long to establish and that this had prevented pupils engaging. Industrial trust visits had been a very popular with the pupils, especially a Year 10 trip to a local power station and a Year 9 visit to a space centre. The school had taken a group of students to the University for the Ashfield Music Festival enterprise event and had subsequently run their own version in school. Although there had been a positive response to the visits, the head of department commented:

> DT1: trips are nice, but it’s that day by day, what they get fed *every* science lesson that actually makes a difference and makes kids want to keep on doing it.’

Careers advice in school D was regarded as ‘very general’, the science teachers were aware of a twenty minute interview in Year 11 for all pupils, but could not elaborate on other careers-based programmes elsewhere in school. When asked how they might advise a hesitant Year 11 student, DT1 thought that it was important for them to a realistic picture of the challenges of other supposedly ‘easy’ subjects and have an appreciation the opportunities afforded by a physics qualification. Teacher DT2 thought that there was often a mismatch in the ‘perceived amount of maths in physics’ and that A level physics used to be more mathematical. If students were turning to their parents for advice, then this could be a factor in the perception that ‘physics is hard’. DT1 also referred to the ‘futuremorph’ website as a resource that the department used for a careers lesson for their Year 10 students.

During the course of the pilot school D moved to teaching separate sciences instead of double award science. Initially DT1 had offered students the choice to study for a complete GCSE in any of the three sciences; she was ‘stunned’ that they wanted to do physics. There was a group of 12 students who studied physics separately after school. DT1 noted that ‘in recent history there’d never been anyone taking A level physics’ and that from this cohort of students several girls went on to do physics. The following year school D offered triple award science to their students. This was a decision that DT1 was able to make after her involvement with Stimulating Physics.

It is of interest that in school D, there was no discussion regarding time constraints or managerial obstacles to implementing any aspect of the Stimulating Physics programme.

6.4 School E – separate interviews with former head of science and a science teacher

School E is an 11-16 school where a small number of students have taken physics post-16. Analysis of NPD data showed that there had been either 3 or 4 students in each academic year. There was an interview with the former head of science (ET1), and another, shorter, interview with a biology specialist (ET2).

Former head of science, teacher ET1

Teacher ET1 had planned CPD during the school day to coincide with staff availability and when she felt they would be more receptive, i.e. not at the end of a demanding school day. She had tried to keep cover to a minimum, included lunch for the teachers and tried to make it into something that people would enjoy doing. A key to arranging the CPD sessions was the 'whole school ethos of supporting each other and providing for whoever needs the time.' There was a consensus among staff that they would be happy to provide cover within school if it permitted activities across each subject area to take place.

ET1 had tried to involve the whole team as they were more 'likely to discuss it afterwards' and that this was an essential step to embed practices. ET1 felt that it was important the teachers were able to take ownership. Consequently the training sessions were optional. Staff were encouraged to attend and 'dip their toes in the water'. ET1 acknowledges that 'you always have members of staff who don't want to engage, if you have a critical mass of people their enthusiasm brings others in.' This relaxed approach by the head of department resulted in sessions being attended by 8 or 9 staff on a regular basis.

The training helped ET1 to monitor the quality of delivery of physics by her staff. She had been surprised that concepts that she had ‘taken as a given’ were not clearly understood by everyone else in the department. Teacher ET1 cited an example of a starter activity where the teachers were asked to draw a force arrow for the gravitational force on a diagram: ‘I’d just drawn a dot and a clear arrow, but they drew lots of arrows and I thought ‘oh dear, there's something that needs addressing here’.’ The CPD is designed to probe the teachers’ understanding in a non-threatening way and ET1 was able to gain valuable insight into the challenges faced by the non-specialist teachers.

With regard to personal CPD, ET1attended the school sessions with her department and the second year summer school, which she said was ‘a really useful networking opportunity’, as was the teachers’ conference at the IOP. ET1 referred to several changes in the department’s teaching approaches that had been written in the schemes of work, for example the ULC/IOP medical physics web resource: ‘treating a tumour’; use of the SPT models including the idea of ‘energy stores’ was also in line with how ITT students were taught.

Teacher ET1 felt more confident after the summer school and that it ‘has made me feel much better about the way that I deliver physics.’ A specific example was that after the summer school she had decided to use the ripple tank, which she had usually avoided in the past, she remarked that her BTEC students had really enjoyed the activity. A fear of equipment failure is common among non-specialist teachers (Millar, 1988). Because ET1 had benefitted on a personal level this will have helped her appreciate how it might improve the confidence of her colleagues. Recognising the *need* for physics CPD for non-specialists in the department and having a personal attitude change would help establish an organised programme in the school.

ET1 discussed other aspects the Stimulating Physics programme. She had thought that pupils did not really engage with the Big Bang Blogs e-mentoring element, and there had only been a few emails exchanged between mentors and school pupils. Year 10 students had participated in the Ashfield Music Festival at a local university. ET1 said that they had 'cherry picked' and have developed a Year 9 unit called 'science goes to the festival' and used ideas for mainstream teaching rather than a separate event. Adapting teaching strategies to work in the school environment shows a high level of engagement with the materials, rather than simply taking an activity off the shelf.

ET1 had attended the one-day careers' event and reflected that it had highlighted that physicists have a much wider variety of careers opportunity. She felt that including careers had become 'an essential part of science teaching' to highlight that a science qualification would open more doors.

Teacher ET1 thought that any new school embarking on SP support should involve the whole team and encourage people to go on events outside school. The networking opportunities were 'invaluable' and contact with other schools had helped to consolidate the training: 'you can get so caught up in the everyday sometimes, it's great to have a chance to take a step back and discuss with other people.'

Alongside changes in resources: curriculum materials and equipment, the most important change that ET1 thought had taken place was that the department now talked about 'how they teach' (Little, 2003). Discussions were informal, but occurred on a regular basis and had spread into other areas of science teaching, as well as physics.

Biology teacher ET2

There was a short interview with teacher ET2, an experienced teacher, who had been reluctant to be involved in the CPD initially, but had decided to attend after feedback from his colleagues. ET2 felt that he had enjoyed the sessions at the time, but for it to be useful he would have to ‘use it straightaway.’ As the topics were taught in rotation at school E he said that ‘it’s never going to be what’s up next for everyone.’ This is a contrast to the arrangement at school D where all the teachers are teaching the same GCSE topic at once.

Teacher ET2 stated that he was four years away from retirement and that he was ‘not so keen on changing how I teach.’ Hebberman (1988) observed that more experienced teachers had less belief that an intervention would be successful and were therefore less ready to participate. ET2 thought that any further training should focus on new teachers who have the ‘right mindset to try something new.....they’re still learning.’ (Sikes, 1992) has suggested that early career teachers, though enthusiastic, lack the skills and experience to be able to affect change.

This highlights that *when* a training topic is selected makes a huge difference to its implementation in the classroom. However, there may be personality factors that have a more influential role, ET2 also noted that he ‘wasn’t particularly keen on using smartboards and did not think that they were a replacement for *real* teaching’. What emerged during our discussion was that he had gained most of his early teaching experience overseas, where he had had little resources to work with and had developed his early pedagogy based on this. He explained in detail, how, on returning to the UK he had been coached by the head of chemistry in key practicals almost immediately before the lesson. There seemed to be an underlying pedagogical approach of 'doing it now', and teacher ET2 assessed that this was probably to do with his 'particular learning style'.

The career stage of the teacher involved has some bearing on their level of engagement. ET2 admitted to being reluctant to change (Hebberman, 1988) and also unwilling to engage with new technology (Sikes, 1992). However, in school D, teacher DT2 had readily embraced and adapted new teaching approaches. He also was approaching retirement. He had mentioned his involvement with the research of Driver at Leeds University. This was several years into his teaching career. Perhaps as a consequence teacher DT2 would appear to have an established mechanism for experimenting with new teaching approaches.

This particular teacher acknowledged that he was reluctant to change his teaching at this late stage in his career. Here SP had left little mark. However, it was clear from the earlier discussion with teacher ET1, the former head of department, that Stimulating Physics had led to several changes in how physics is taught by many of the teachers and encouraged them to engage in regular discussion regarding all aspects of their science teaching.

6.5 Teacher interview summary

New teaching strategies had been embedded in schools where the head of department took an active role in the training and worked alongside their colleagues. It is interesting to note that the teachers in these schools (D and E) teachers had remained in post rather than seeking positions elsewhere and that these are both 11-16 schools.

The most effective method for promoting the CPD in school was to gently encourage rather than impose the training on a particular group of teachers and provide time during the school day. There also needs to be time for discussion among colleagues to reflect on how they have implemented teaching strategies with *their* students.

7 Conclusions

The impact of the Stimulating Physics has been explored using secondary data from the National Pupil Database and there have been statistically significant increases in student uptake at AS and A2 level from 2005/2006 to 2009/2010. Student focus groups were used to probe the factors behind student choice and teacher interviews identified mechanisms that helped support effective teacher professional development in schools.

7.1 Analysis of student uptake post-16

The Stimulating Physics pilot has had a positive effect on student uptake post-16. It has exceeded its original aim of a 30% increase in the *number* of A level students. There was an overall increase of 55.8% from 2006 to 2010 in SP schools compared to 34.6% in the control schools in the Leeds, Nottinghamshire and Oxfordshire regions.

The use of National Pupil Database to provide secondary data enabled comparisons of the percentage uptake of physics on a school by school basis for all the educational establishments in the participating region. There were statistically significant differences (p=0.036) in the AS student data for Leeds and Oxfordshire, where SP schools uptake had increased from 5.9% to 13.1%, compared to 6.3% to 10.8% in the control schools from 2005/2006 and 2009/2010. (There was a large proportion of missing data from the NPD Year 12 records for the Nottinghamshire region, students had not claimed their AS qualifications at this stage and had deferred this till the following academic year, data was not available for 2010/2011 at the time of analysis.)

Analysis of A2 data for all three regions revealed that although the number of students had increased for both the SP and control schools, the total percentage uptake had remained relatively static for SP schools from 6.4% to 6.3%, compared with a slight decrease in the control schools from 8.7% to 8.0%. There was a slight peak in 2008/2009, which is linked an increase in AS uptake for the preceding year. This could be due, in part, to the Hawthorne effect (Cook, 1962), although many physics specialists had attended teacher events and this may have helped them to raise the profile of physics in school at an early stage in the programme.

All AS and A2 pupils were tracked back to their Key Stage 4 school, this was a necessary step in following 11-16 school pupils to the post-16 course. From a preliminary analysis in the Leeds sample it became evident that high number of pupils (35%) change from their original school at the end of Year 11. Any effect due to the intervention could be masked by the large degree of movement between establishments post-16. In order to gauge the effectiveness of the SP invention which focussed on KS3 and KS4 students the data was manipulated to provide a KS4 reference number for each KS5 student in the record. All analyses of uptake was based on the students' KS4 school and was a measure of the number of students each school had *provided* for AS and A2 physics courses.

The UKRC had been a partner in the pilot and had provided training for teachers, organised action research project as part of the IOP's existing 'Girls in Physics' project (Murphy & Whitelegg, 2006). The largest increases were seen in the Leeds region which had focussed support from the UKRC and had organised careers-based events with role models for Year 10 students.

7.2 Factors effecting student choice

Focus group interviews with students revealed that it was more likely for students to have had direct exposure to the new teaching methods in schools where there was a smaller proportion of physics specialists. Students in two of the three schools could recall specific visits or events that had taken place. Pupils in school B spoke with enthusiasm about SP visits and could recall a specific SPT teaching approach being used by their subject teacher. The majority of students referred to teachers and the lessons as being instrumental in their choice of physics at AS level.

Students thought that careers advice had been limited and they perceived a vocational bias, although some had not opted for a careers' interview in school at all. School B students seemed to have received advice to 'keep their options open' and had chosen a combination of science, maths and humanities subjects. Often students choose biology as their sole science subject at AS level, but students in school B had favoured physics.

7.3 Teachers' views on the Stimulating Physics pilot

There was a wide variation in the degree of change evident in the four schools. An established programme of support had taken place where whole school policies were in place to support staff CPD: providing opportunities for subject specific CPD, valuing staff development and encouraging a team ethos between departments, allowing time for subject-based training (Opfer & Pedder, 2011; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). The school management teams were also instrumental in releasing students and staff for off-site events.

Within the science department, key factors for a successful training programme were that the head of department recognised the need for physics support amongst non-specialists and was in a position to orchestrate a regular training programme. It was important that the head of department committed to the project at an early stage and gained an appreciation of how the CPD could aid their department, reinforced by direct personal involvement.

When a whole department or a critical mass of teachers was involved new ideas could be discussed after the CPD sessions and in the context of their school setting. Garet (2001) notes that discussion amongst teachers who are facing similar issues helps to encourage problem solving and fostering a belief that change is possible. A 'collegiate atmosphere' (Clarke & Hollingsworth, 2002); Guskey, 2000; Opfer & Pedder, 2011; Penuel et al., 2007) can help teachers work through difficulties together and achieve common goals e.g. a sense of security when teaching physics and establishing opportunities to trial new teaching techniques.

A supportive ethos within the whole school and the science department both aid the individual teacher's participation in CPD. Being given the opportunity to *choose* to participate is an indication of respect for the teacher's professionalism. Conversely, having change enforced may be regarded as being critical of the teachers' abilities and damaging to morale (Sikes, 1992). Opfer and Pedder (2011) found that in lower achieving schools professional learning may have a negative association with teachers' poor performance and be regarded as a punishment. A subject leader who helps to encourage a relaxed, elective approach to CPD helps to establish a sense of trust and ownership among the teachers (Sikes, 1992). There is evidence from the teacher interviews and increased student uptake that lower achieving schools can engage effectively in a CPD programme provided that there is a strong commitment on the part of the subject leader. This was seen in schools B, D and E where the subject leader had attended summer schools and engaged in regular CPD with their colleagues. In the case of school B, the lead teacher had subsequently retrained as a physics specialist on the Science Additional Specialism Programme.

There is often a deeply-rooted ‘fear of physics’ that stems back to the individual teachers’ school science education. Frequently a non-specialist has made the decision not to pursue physics beyond the post-compulsory phase. Teacher DT1 referred to ‘a back history…that you’ve never felt confident about’. It is a huge personal risk to expose oneself in front of colleagues. Establishing an atmosphere where the teachers feel secure enough to discuss their perceived difficulties openly is central to the success of a CPD session and is heavily dependent on the ethos that already exists amongst the department. Although the Supporting Physics Teaching training format shifts the focus away from the teachers by encouraging review of students’ starting points, the session structure needs to adapt to the group dynamic within each school.

Within the teachers interviewed, regular attendance of CPD sessions, and particularly, at the summer schools indicated a firm commitment to the SP programme. This was a small sample of interviewees, but the most change with regard to student uptake had taken place where a large group of teachers had attended the summer school together in schools B and D.

7.4 Critique of the methodology

The task of obtaining data from schools took much longer than anticipated and the return rate was much lower than expected. A combination of teacher records and examination entry data was returned by the schools and it was evident that teachers do not have easy access to past student numbers on their courses. Communication was hampered by the fact that many of the lead teachers had moved on and effectively the schools were being contacted ‘cold’. Of note, was that the questionnaires sent out to existing Stimulating Physics schools were completed fully and with a 60% response rate. It seems that being engaged in regular communication with the IOP and in a position to benefit further from support helped secure a response.

If the research were to be replicated, secondary data from the National Pupil Database would be used from the outset as it is an objective and reliable source of rich data which tracks each pupil throughout the course of their school education, for example, as they move between schools. In addition, this approach is more efficient for the researcher, and does not place an additional burden on teachers and schools to collect data for the project.

Schools A and C had a sufficient number of physics staff to teach the physics component of the GCSE science course; there was no evidence of new physics teaching strategies in these schools. To fully assess classroom-based activities pupils taught physics exclusively by non-specialists would need to be interviewed. This would typically be with Key Stage 3 pupils.

7.5 Suggestions for further research

The National Pupil Database contains an extensive amount of pupil data. The quantitative aspect of this research focussed solely on physics uptake, however the following factors could all be investigated using the secondary data available:

- whether science and maths grades at GCSE act as indicator of retention, and performance at in physics at AS and A2;

- to what effect does GCSE science specification affect student choice and attainment in physics post-16;

- how ethnicity influences on student choice of physics post-16; this has been noted to be a more influential factor than gender (Greenfield, 1995).

7.6 Recommendations for the Stimulating Physics Network

Secondary data from the National Pupil Database has been used to measure the impact of the SP pilot on student numbers at A level. The approach could be extended to assess the current phase of the SPN which is working with approximately 280 schools nationally. Due to the large range of data available other effects on student uptake could be investigated, for example: prior attainment at KS3 and KS4; AS subject combinations that lead to greater retention of physics at A2 and the effect of exam specification on uptake and retention of A level physics.

Many of the student initiatives in the pilot focussed on Year 10 pupils, and this would appear to have had an effect this cohort choosing physics when in Year 12. The most noticeable change in AS uptake occurs for the Year 10 students from 2007/2008. Research suggests that engagement activities would be more effective with younger students at Key Stage 3 (Archer et. al, 2010; Osborne et al., 2003; Reid & Skryabina, 2003), a sentiment echoed by the male physics students that were interviewed.

However, the female students thought that younger students were not sufficiently focussed, and that attention should be concentrated on GCSE students.

All students felt that they would have benefited from clearer advice regarding career paths afforded by their subject choices. Some had been influenced by information permeating down from teacher events at the IOP, however both teachers and students felt that there needed to be more structured guidance. This could form a more central core of activities of the SPN.

The number of girls opting for physics had also increased slightly. This was most marked where schools were encouraged to participate in action research, alongside careers focussed events for female students. It would seem sensible to adopt a similar approach in existing SPN schools, subject to the schools' capacity.

Teacher reflections have shown that the teaching strategies and pupil engagement activities are more likely to be embedded in schools were the subject leader takes an active role in the subject-specific CPD. Therefore, it is essential that the subject leader is committed to the aims and ethos of the SPN at an early stage and is in a position to negotiate provision of teachers' time for CPD with the school senior management team, in addition to sanctioning pupil engagement activities.

Recruitment of new schools to the SPN would need to establish the level of capacity for teacher development at an early stage. Student attainment has been used as part of the criteria for inclusion in the SPN focussed CPD. However, there would appear to be a dichotomy, in that lower performing schools, most in need of support, are more likely to lack the necessary level of practice to facilitate professional learning (Opfer & Pedder, 2011). There is a delicate balance to be struck between providing professional development that is engaging and appealing to science teachers within a more rigid framework of structure support within the schools' management structure.

The Stimulating Physics pilot made a substantial difference to student numbers; teacher attitudes and practices in lower performing schools, particularly in those schools where there was an under-representation of physics specialists within the science department. Enduring change can take place where there is inspiring leadership in the science department and a core group of teachers working together to effect positive change in the teaching and learning of physics in their schools.

Appendix A : Questionnaire on student science uptake

Leeds/Oxfordshire/Notts*

*Please delete as appropriate

School:

Please enter the number of students *starting* AS level courses

(enter figures for girls and boys if known, otherwise just use total)

Post -16 course	Actual number of students *starting* post-16 courses:				
	in 2006	in 2007	in 2008	in 2009	in 2010
AS biology					
girls					
boys					
AS chemistry					
girls					
boys					
AS physics					
girls					
boys					

Please enter the number of students *starting* A level courses

(enter figures for girls and boys if known, otherwise just use total)

Post -16 course	Actual number of students *starting* A level courses				
	in 2006	in 2007	in 2008	in 2009	in 2010
A2 biology					
girls					
boys					
A2 chemistry					
girls					
boys					
A2 physics					
girls					
boys					

Please select the GCSE science course that was taught to the AS students

Year	in 2006	in 2007	in 2008	in 2009	in 2010
Specification					

Appendix B Data requested from the National Pupil Database

Key Stage 5 data requested for academic years 2005/2006 to 2009/2010

NPD Alias	**Description**
KS5 Candidate Table	
ks5_PupilMatchingRefAnonymous	Pupil matching reference - Anonymous.
ks5_YEARGRP	Year Group - derived from date of birth.
ks5_ACTYRGRP	The actual National Curriculum year group that the pupil follows within the school, including pupils in Independent schools (AAT data).
ks5_GENDER	Gender.
ks5_LA	Local Authority (LA) that the school where the pupil attends reports to (original data).
ks5_ESTAB	*Establishment number of the school attended as assigned by the DfE (original data).*
ks5_URN	School's Unique Reference Number
ks5_GA_PHYSICS	Grade achieved at GCE A Level Physics.
ks5_GAS_PHYSICS	Grade achieved at GCE AS Level Physics.

Key Stage 4 data requested for academic years 2004/2005-2008/2009

NPD Alias	**Description**
KS4 Candidate Table	
ks4_PupilMatchingRefAnonymous	Pupil matching reference - Anonymous.
ks4_YEARGRP	Year Group - derived from date of birth.
ks4_ACTYRGRP	The actual National Curriculum year group that the pupil follows within the school, including pupils in Independent schools (AAT data).
ks4_GENDER	Gender.
ks4_LA	Local Authority (LA) that the school where the pupil attends reports to (original data).
ks4_ESTAB	*Establishment number of the school attended as assigned by the DfE (original data).*
ks4_URN	School's Unique Reference Number

Appendix C : Lead teacher email

Dear «Leadteacher»,

I hope that this finds you well and would like to thank you for the support of the Institute of Physics Stimulating Physics pilot at «School_». The science department had a series of CPD sessions with our Regional Advisor from January 2007 to July 2009. From the region, teachers attended our summer schools in Oxford and York to further their professional development. Pupil engagement activities included the Ashfield Music Festival Business careers simulation; visits with the Industrial Trust; Online Networking and Girls in Physics events. As a consequence of the success of the pilot, the Stimulating Physics Network continues to thrive and has recently secured funding from the DfE until March 2012.

As a follow up to the Stimulating Physics' pilot I am researching the impact on student uptake of A level physics as part of a Masters in Education by Research at York University. The initial stage is to collect data regarding AS and A level science classes for the last five years. Please find a copy of the questionnaire attached to this email RH_stimphys_survey.xls. Please enter Leeds/Oxfordshire/Nottinghamshire for region, as appropriate.

I would also like to arrange a visit to «School_» and interview year 12 students regarding their subject choices, at a time that is convenient for staff and students. Ideally, I would like to conduct the interviews by the end of the Spring term in order to cause the least disruption in the lead up to exams. However, I anticipate that interviews will take approximately 40 minutes, and that they can be accommodated into the school day. Students will be advised that any record of the interviews will be anonymous and they are welcome to view a transcript if preferred. I would also like to discuss with teachers involved in the training how they feel the programme has impacted on their physics teaching.

As I am employed as a teaching and learning coach in the Yorkshire and Humber region, I have a full CRB check to work in schools supported by the Institute of Physics. If your science teachers attended our summer schools in Oxford or York, then I should be a familiar face.

Please could you take a few minutes to complete the attached survey and email back to me at rachel.hartley@iop.org. I look forward to visiting «School_» and hope to see you in the next month or so.

Best wishes,

Rachel Hartley

Appendix D   Head teacher permission letter

Dear <Headteacher>,

I hope that this finds you well and would like to thank you for the support of the Institute of Physics Stimulating Physics pilot at <<school>>. The science department had a series of CPD sessions with <<regional advisor>> from January 2007 to July 2009 and teachers attended our summer school in Oxford/York to further their professional development. Pupil engagement activities included the Ashfield Music Festival Business careers simulation; visits with the Industrial Trust; Online Networking and Girls in Physics events. The Stimulating Physics Network continues to thrive and has recently secured funding from the DfE until March 2012.

As a follow up to the Stimulating Physics' pilot I am researching the impact of the Stimulating Physics' pilot on student uptake of A level physics as part of a Masters in Education by Research at York University. The initial stage is to collect data regarding AS and A level science classes for the last five years. I would also like to arrange a visit to <<school>> and with the help of <<leadteacher>> interview year 12 students regarding their subject choices, at a time that is convenient for staff and students. Ideally, I would like to conduct the interviews by the end of the Spring term in order to cause the least disruption in the lead up to exams. However, I anticipate that interviews will take approximately 40 minutes, and that they can be accommodated into the school day. Students will be advised that any record of the interviews will be anonymous and they are welcome to view a transcript preferred. I would also like to discuss with teachers involved in the training how they feel the programme has impacted on their physics teaching.

As I am employed as a teaching and learning coach in the Yorkshire and Humber region, I have a full CRB check to work in schools supported by the Institute of Physics. If your science teachers attended our summer schools in Oxford or York, then I should be a familiar face.

Please could take a few minutes to complete the attached permission form and return in the enclosed envelope. I look forward to visiting <<school>> and hope to see you in the next month or so.

Best wishes,

Rachel Hartley

Appendix E   Head teacher permission form

I am happy for Rachel Hartley to visit <<school>> during the Spring and Summer term, 2011 to interview students regarding their subject choices in post-compulsory education. I understand that Rachel Hartley holds a current CRB check and that any students' or teachers' comments will remain anonymous if reported as part of her MA dissertation.

Signed ________________________________ Date:________________

Appendix F Student interview schedule

Student interview schedule (45 minutes)

Introduce myself and outline aim of my research. Stress anonymity and advise that I am recording the interview and will transcribe it later.
Ask students to introduce themselves, offer refreshments.

AS choices

1. What other subjects are you studying?
2. Who did you discuss your AS choices with?
3. What do your family and friends think about you studying physics?
4. When do you start to think about studying physics beyond 16?

Classroom experience

5. Describe the most interesting physics lesson you've had
6. How would you advise a year 11 pupil thinking about taking physics?
7. What topics do you find most engaging and why?
8. What makes a good physics' lesson?
9. What makes a bad physics' lesson?
10. What makes a good physics' teacher?
11. What makes a bad physics' teacher?
12. Would you consider being a physics teacher?

Careers

13. Do you have any firm career plans?(prompt)
14. What's a really exciting job?
15. Do you know what opportunities are available by studying physics at University?(prompt)
16. Other than your teacher, can you tell me about a physicist that you've met?
17. How will you find out about what university course you'd like to study?
18. **How do you think more pupils could be encouraged to take physics?**

Physics content

19. What do you like most about studying physics?
20. What do you find the most challenging/difficult?
21. What models do you remember using when you learnt about?
22. Forces, electricity, energy

Other factors

23. How often do you talk about your physics course at home?
24. When/what do you read about physics outside of your studies?
25. What physics' programs do you like to watch on TV?
26. What websites would you recommend to another student?
27. Are there any other hobbies/interests that you'd like to mention?

28. Is there anything that you'd like to ask me?

Appendix G Teacher interview schedule

Teacher interview schedule (30 minutes)

Introduce myself and outline aim of my research. Stress anonymity and advise that I am recording the interview and will transcribe it later.

Thank them for their time.

Background

1. What's your specialism?
2. How many years teaching?
3. What level do you teach physics to?
4. How have you been involved in the stimulating physics project? CPD/summer schools?

Classroom experience

5. Classroom effects
6. Pupil behavior
7. Pupil engagement
8. What advice would you give a year 11 student who thinks physics is too hard?

Departmental changes

9. Courses taught?
10. SoW
11. Pedagogy
12. What advice would you give another school embarking on project

Obstacles/difficulties in implementing in house CPD programme?

Benefits – classroom, department, whole school?

What has been the most significant change(s) Stim Phys has made?

How can you be further supported by IOP

Is there anything that you'd like to ask me?

Glossary

A2	Examinations taken in the second year of A level, typically taken in Year 13
AS	Advanced subsidiary qualification, equivalent to half an A-level and typically taken in Year 12
CPD	Continuing professional development
CRAC	The Careers Research and Advisory Centre
DfES	Department for Education and Skills DfEE Department for Education and Employment
GCE	General Certificate of Education
GCSE	General certificate of secondary education
HEFCE	The Higher Education Funding Council
HESA	The Higher Education Statistics Agency (HESA).
IOE	Institute of Education
IOP	Institute of Physics
JCQ	Joint Council of Qualifications
LEA	Local Education Authority (latterly know as Local Authority)
NPD	National Pupil Database
SPN	Stimulating Physics Network, national phase that followed the Stimulating Physics pilot
SPT	Supporting Physics Teaching materials developed by the IOP
UKRC	UK resource centre for women in SET (science, engineering and technology
YCS	Youth Cohort Study

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