Improving Take up of Science and Technology Subjects in Schools and Colleges: A Synthesis Review

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Research Synthesis

This Research Synthesis is commissioned by the Economic and Social Research Council (ESRC), as part of its Science in Society Strategy, jointly with the Department for Children, Schools and Families (DCSF). The prime purpose of the Research Synthesis is to gain a better understanding of successful interventions and practices used by schools and colleges to reduce drop-out rates in science, technology and mathematics subjects.

Background

Science, technology, engineering and mathematics (STEM) subjects are identified as being 'critical' to the future industrial competitiveness of the UK (Science and Innovation Investment Framework 2004-2014) and are of strategic importance to the nation due to increased competition from rapidly advancing economies around the world. However, over the last decade, the UK has experienced a marked decrease in the number of A-Level students taking mathematics, chemistry and, in particular, physics. There is a pronounced gender gap in the number of females taking science subjects at A-Level, principally physics and mathematics. Some ethnic minority groups attain significantly below the national average and their under-achievement in science and mathematics subjects, in general, is much greater than the gap between boys and girls. Moreover, there is a particular concern as to why more pupils who do the core science and mathematics A-Levels subjects opt out of studying these subjects for their degrees and why a significant proportion of science and mathematics graduates choose not to pursue related occupations (Jones and Elias, 2005; Wynarczyk 2008).

Research carried out for the Wellcome Trust in 2005 found that children, in general, experience a diminishing interest in science subjects from the age of ten onwards. Prior to this age, children's interest in science is found to be generally high, equally, amongst boys and girls. It also shows that the final years of primary school form the critical points of decline, particularly amongst girls (Murphy & Beggs, 2006; Osborne, 2007).

Diminishing interest in science subjects is, amongst several other factors, attributed to, the lack of knowledge and understanding of the real importance, values and contribution of science to everyday life, gender, the traditional methods of teaching, lack of the availability of sufficient qualified teachers and the general negative attitudes of young people towards science.

The UK Government strives to preserve interest in science, technology, engineering and mathematics (STEM) subjects at secondary and tertiary level education. It has continued to show a firm commitment and is determined to identify new ways and inject more money to motivate and inspire many more young people to take up STEM subjects and achieve good results, following their journeys into the STEM pipeline, i.e., taking up science subjects post-16 study and university or vocational education and, subsequently, moving on into rewarding and progressive careers (DCSF, 2008).

The Government is actively encouraging greater participation of pupils in STEM subjects and allied fields through an extensive and overwhelming array of national and regional bodies, initiatives, programmes, schemes, academies, new qualifications and diplomas. Despite recommendations made by the STEM Cross-Cutting Programme, carried out in 2006 on behalf of the UK Government, which has concluded that '*at the current time there are far too many schemes, each of which has its own overheads…., there is a need, therefore, to rationalise those supported by the Government and build on the best ones. By doing so, a much better result can be achieved for the same amount of money (DfES, 2006a: p.3).* Recently the Government has substantially increased its STEM education budget and activities in an attempt to reverse the current STEM trends.

On 24 January 2008, the Schools Minister Jim Knight announced and outlined a new strategy with a budget of £140 million to educate the next generation of scientists and mathematicians and aid to recruit and train more science and maths teachers. The £140m package, which covers the period 2008 to 2011, is said to be more than double the amount spent between 2005 and 2008, underpinning the government's commitment to increase the number of science and maths teachers, improving results at GCSE and increase the number of young people studying these subjects post-16. The package includes £9 million to improve pupils' learning experience through enhancement and enrichment activities and doubling the number of science and engineering clubs in schools from the existing 250 to 500 (DCSF, 2008).

In 2004, a STEM Mapping Review conducted for the UK Government revealed over 470 STEM initiatives which were established by the then DfES, DTI and external agencies. The vast majority were targeted at primary and secondary sector, mainly, focused on science and mathematics as two priority areas. Since the production of that Review, new initiatives and schemes are emerging continuously at national, regional, and local levels.

STEM bodies, organisations, initiatives, measures and schemes, in aggregate, form the major components of STEM activity and the Government's expenditure. In general, they share a common mission, i.e., to inspire and equip children and young people to become the scientists of tomorrow. They have been set up to address the serious concerns over downward trends in STEM and help to ensure a better transition in the ‘STEM pipeline’, from interest at GCSE level to A-Level, diplomas, further and higher education and career.

Whilst STEM education budget, initiatives and schemes continue to increase in terms of numbers and activities, the real impact on improving the take up, performance and achievement in STEM subjects has not been investigated. This is a highly neglected area of research and policy.

Only a small proportion of these initiatives and schemes provide contact details of participating schools, teachers and pupils. Few initiatives and schemes provide case studies or success stories of participating schools, which tend to echo the participants’ positive views and comments, publicised via their websites and newsletters. However, case studies, although limited in numbers, when compared with the number of initiatives and schemes that currently exists, provide information about the nature of the projects and activities supported and, as such, provide an invaluable source for the identification of good practice and innovative practices that have the potential to be replicated elsewhere in other schools and which may have the potential to become permanent features of the science subjects, qualifications and diplomas.

Existing academic research and government reports focus, principally, on the identification of factors that positively or negatively influence the take up of science subject at schools and beyond. There is a huge body of research on the topic of the views and attitudes of young people towards science (see for example, Brown, 1976; Doherty and Dawe, 1988; Bennett, 2001; Osborne and Collins 2001; and Osborne et al, 2003).

Limited studies, evidence and evaluation of STEM initiatives, grants and schemes that currently exist are largely based on views expressed and comments made by teachers and pupils who have participated in their initiatives and schemes (see for example, Murphy and Beggs, 2006) as opposed to any serious attempts to measure and demonstrate the real impact on reducing the drop out and better achievements in STEM subjects. There has been no major survey of schools and colleges that have participated in different initiatives and schemes, let alone those which have instigated their own innovation measures and interventions. It is only through such investigations that successful interventions, initiatives, bodies and schemes can be identified and promoted. At the present time, there is no repository or focal point of co-ordination of these initiatives and with a large number of other national, regional and local non-governmental organisations and initiatives that are also involved, it has been virtually impossible to view and consult all the websites (the main source of information) to extract relevant information about their activities and participating schools.

It is against this background that this Research Synthesis has been conducted.

Aims and Objectives

The Research Synthesis attempts to explore, through an examination of existing research, reports, policy and publicly available information, what has been learned from secondary and college level institutes which have instigated different practices to retain students in science and technology subjects and identify any trends in this area, where possible. The Synthesis provides a review of research relating to uptake, as well as a resource for policy and decision makers in science, government, industry and the education field.

The Synthesis aims to:

- undertake research around the topic of pupil retention in science and technology courses;
- analyse trends which may appear (such as gender, age or geographic factors which may affect the success of innovative initiatives); and
- produce a resource via a written report and PowerPoint presentation for stakeholders.

Methodology

The methodology of this study incorporated a combination of literature reviews, desk research, web searches, qualitative and analysis of publicly available databases, where applicable. The methodology acknowledges the literature, governmental and non-governmental reports, bodies, organisations, policies, initiatives, schemes, and programmes relating to STEM activity at primary and secondary education levels.

The desk research has included:

- An overview of existing innovative, new and emerging initiatives, programmes and practices designed to encourage greater take up of science subjects, as well as progression and retention in the science ladder (pipeline) amongst schools and colleges in the UK.
- An assessment of the take up of these initiatives by schools and colleges and their effectiveness and impacts.
- An overview of innovative existing, new and emerging courses, qualifications, and diplomas.

- An overview of innovative existing, new and emerging initiatives, courses and educational programmes that aim to meet the needs of specific groups.

- An overview of academic research, reports and publications which have identified relevant schools and colleges together with the innovative practices used.

- Identification of best practice that may be replicated elsewhere, as well as gaps in academic research, policy and practice.

Numerous academic studies and government reports have attempted to identify the factors that may have positive or negative impacts on the take up of science subjects, achievements and subsequent choice of remaining in the science pipeline, i.e., pursuing further education and eventual careers in science (see for example, Osborne, 2004, 2006; Murphy and Beggs, 2006; Haste, 2004; ETB, 2005, 2007; Roberts, 2002; Wynarczyk, 2006, to name but a few). Sir Roberts Review has identified four main factors, namely, teachers and their style/method of teaching; the teaching environment; the subject curricula and subject-related extra-curricular activities; as well as several other influences, such as the views of parents, teachers and the society as a whole. Research and policy initiatives tend to focus on one aspect or factor. In terms of research, there is an over emphasis on the identification of factors, such as 'attitude' that influence the decision of pupils to pursue science post primary education, when taking up science subjects is no longer compulsory.

As Sir Roberts Review has correctly highlighted, quantitative and empirical evidence on relative importance, cumulative effects of, and interrelationships between separate but equally important factors are scarce. Sir Roberts Review states that 'tackling any one aspect whilst neglecting others is unlikely to deliver a strong overall improvement' (Roberts, 2002, p.50).

This Research Synthesis attempts, where possible, to provide an overview of different components of STEM activity, focusing on several key factors which are the main target of STEM initiatives and schemes, namely: teachers, and their style/method of teaching and the teaching environment; science, design and technology laboratories, gender, ethnicity and role models.

It sets out to propose a contextual framework for more effective ways of the co-ordination of the whole STEM education spectrum in order to assess the real impact of government policy which has already resulted in the development of numerous initiatives, on the take up of science subjects at schools and colleges. It is envisaged that key findings, existing gaps in knowledge, good practice, and recommendation, if implemented, will assist the UK Government to achieve its ambitious targets which are set out in the 'Science and Innovation Investment Framework, 2004-2014' to remedy the current unsatisfactory level of STEM trends.

This Research Synthesis Report consists of several sections. Section one provides a brief overview of science and mathematics trends at the primary and secondary levels. Section two provides a literature review on factors influencing the take up of science and mathematics subjects at schools and colleges. Following this section, several factors that are main target for government policy and STEM initiatives, namely, teachers, and their style/method of teaching; the teaching environment (section 2.1); the importance of role models, mentors and ambassadors (section 2.2); science, design and technology Laboratories and Equipment (section 2.3); and gender imbalance in STEM (section 2.4). These subsections also provide an overview of some relevant and specific initiatives and policies. Section three focuses on regional disparities in STEM trends at the primary and secondary education levels in the UK. Section four focuses on some key initiatives and interventions that are designed to encourage greater take of STEM subjects at schools and colleges. This section consists of two parts. The first part provides an overview of STEM bodies and Initiatives. This part also examines selected initiatives that can be identified as examples of good practice. The second part provides an overview of new STEM qualifications and diplomas. Section five provides an overview of UK Government STEM policy with regards to take up of science subjects at schools. The final section provides a summary of the background, gaps in knowledge, examples of good practice, as well as a number of recommendations.

Section 1: Setting the Scene: A Brief Overview of Science and Mathematics Trends at the Primary and Secondary Education Levels

Science and mathematics subjects are identified as being 'critical' to the future supply of qualified scientific workforce and are of strategic importance to the nation because of the increased competition from rapidly advancing economies around the world (HMSO, 2004).

In the USA, 'mathematics' has been identified as the 'critical filter', acting as a gateway to many scientific fields of study and highly paid careers (Watt, *et al*, 2006; Wynarczyk, 2006).

Over the last decade, the UK has experienced a marked decrease in the number of A-Level students taking mathematics, chemistry and, in particular, physics. In fact, it has been suggested that physics is in danger of disappearing as a subject in 'its own right' from the state education system due to redefinition of general science and shortage of qualified science and mathematics teachers (Smithers and Robinson, 2005). It has been suggested that this may also apply to chemistry but to a lesser degree (Moor *et al*, 2006).

In general, there is a particular concern as why more pupils, particularly girls, who do the core science and mathematics A-Levels opt out of studying these subjects for their degrees and why a significant proportion of science and mathematics graduates choose not to pursue related occupations (Wynarczyk, 2008).

DfES has recently produced a major report on Gender and Education. It summarises current statistics on the participation and attainment of boys and girls from the Reception Year to the Sixth Form, including participation in STEM subjects. The report concludes that girls outperform boys in science, technology and mathematics subjects at GCSE and A-Level. In attaining A*-C grades at GCSE level, although girls tend to have a large advantage of around 10 percentage points in the arts subjects, compared to a smaller advantage of around 5 percentage points in the science and maths subjects, there is a downward trend in real terms in the total number of girls studying mathematics, and the physical sciences (DfES, 2007a). This is a serious signal of a future shortage of people in the STEM labour force if the number of boys studying these subjects falls or remains the same (Roberts, 2002).

The gender imbalances in STEM subjects has become even more pronounced post-secondary education where young girls and women progressively depart from what has become known as the 'STEM leaky pipeline' (Wynarczyk, 2007a).

Participation in STEM subjects varies among different ethnic minority groups. In terms of their percentage of the general UK population, Chinese, and Indian people are over-represented in STEM compared to their White UK counterparts. In contrast, some ethnic minority groups attain significantly below the national average and their under-achievement is much greater than the gap between boys and girls. African-Caribbean people are most severely under-represented in STEM education in the UK, due to the inequalities of their educational outcomes in mainstream education, and unequal access to role models and promotional activities in STEM. Bangladeshi people are also under-represented in STEM both in terms of occupations and educational attainment, with the problem of under-representation being more prominent among Bangladeshi girls and women (Jones and Elias, 2005; Gago, 2004; EMSET, 2004; DfES, 2007a).

There are also regional disparities, in terms of participation in STEM subjects, across Great Britain. A recent mapping exercise carried out on behalf of the UK Resource Centre for Women in SET revealed that in 2005/06 the achievements in core STEM subjects at primary and secondary levels varied across the English regions, Scotland and Wales. The lowest performing region was Yorkshire and the Humberside particularly for Physics, Double Award Science and Mathematics. In the same year, the achievements of pupils in Scotland and Wales were below UK national average in STEM subjects (Wynarczyk, 2008). STEM subjects, in terms of participation, attainment and achievement amongst pupils at primary and secondary education located in different regions of England, Scotland and Wales have not been the subject of a comprehensive investigation in 'its own right'.

Sir Roberts Review used STEM data in 1999 to consider whether there were notable differences in the take up of and performance in STEM subjects amongst pupils from different regions. The report concluded that pupil choices at A-level did not vary greatly between regions, although a greater proportion of students in the London region seemed to choose mathematics and chemistry than in other regions. As such, Sir Roberts Review did not make any recommendations about regional disparities and their causes (e.g., socio economic factors) and, as a result, demographic issues have received very little attention and consequently remain a neglected area of research and policy (Roberts, 2002).

Section 2: Factors Influencing the Take Up of Science and Mathematics Subjects at Primary and Secondary Education: A Review of the Literature

The pupil's engagement (or lack of it) in STEM subjects at schools has been the focus of attention of numerous studies for over several decades (see Osborne, 2003 for an overview of the literature), particularly since 1950s when science in primary schools did not develop significantly due to lack of teacher expertise, lack of resources, large classes and the added pressure of the eleven plus examination (Murphy and Beggs, 2006). The changes in the UK science curriculum since the 1960s, a crucial decade when science became compulsory at the primary level, have largely reflected a growing acceptance that "science is a subject for all students up to age 16 rather than one chosen by a minority as a preparation for more advanced study" (ASE, 2006, p.9). This is believed to have infused significant interests amongst the research community to identify and examine those factors that, positively or negatively, influence the attitude and take up amongst pupils, particularly at post primary education.

Numerous academic studies and government reports have attempted to identify factors which may have positive or negative impacts on take up of science subjects, achievements and subsequent choice of remaining in the science pipeline, i.e., pursuing further education and eventual careers in science (see for example, Osborne, 2004, 2006; Murphy and Beggs, 2006; Haste, 2004; ETB, 2005, 2007; Roberts, 2002, to name but a few). Current research suggests that the diminishing interest in school science subjects may be, amongst many other factors, attributed to the lack of knowledge and understanding of the real importance, values and contribution of science to everyday life; the traditional methods of teaching; the availability of sufficient qualified teachers; mismatch between the values communicated by science and the manner in which it is taught; the aspirations, ideals and developing identity of young adolescents; the negative attitudes of young people towards science in general; gender; and lack of understanding and appreciation amongst young people of their potential future role, responsibility and contribution to education, industry and scientific, and technological advancement once they turn into adults.

Existing research reveals that children, in general, experience a diminishing interest in science subjects from the age of ten onwards. Prior to this age, children's interest in science is found to be generally high, equally, amongst boys and girls. It also shows that the final years of primary schools form the critical points of decline, particularly amongst girls (Murphy & Beggs, 2006; Osborne, 2007). Such observations have resulted in an increased emphasis on engaging children's interest in science in the transition from primary to secondary school through extra curricular activities.

One recent US study carried out by Tai, et al in 2006, suggests that by the time pupils reach the age of 14 their interest in pursuing post-secondary education and a career in science is a forgone conclusion. Their research reveals that those pupils who show an interest in pursing a science career before the age of 14 are 3.4 times more likely to earn a STEM degree compared to pupils who have expressed an interested in a non-science career. Furthermore, students who demonstrate a high ability in mathematics are 2.7 times more likely to undertake a STEM related post-secondary education and career compared to those who do not express a similar interest (Tai, *et al*, 2006). This suggests that developing pupils' interest and engagement in STEM activities at a very early age may be a strong determinant in influencing their longer term career choices. Indeed, the socialisation and conditioning of children is likely to result in subject and career choices shaped from an early age (British Council, 2001; EOC, 2001).

Research suggests that while there is a natural tendency for some children and young adults to shy away from certain STEM subjects, Udo *et al*, (p. 435) state that "*students'* *choices of college courses and future careers are often dictated by how comfortable they feel about certain subjects. … it is not uncommon for students to shy away from or perform poorly in science courses*". This phenomenon was referred to by Mallow (1986) as 'science anxiety' and its mathematics counterpart by Tobias (1978) as 'maths anxiety', which has been found to affect girls more than boys (Udo, *et al*, 2004).

The following sections explore further some of the factors influencing the take up amongst young people and are part of the Government education budget and main target for STEM initiatives.

Section 2.1: Teachers, and Their Style/Method of Teaching; the Teaching Environment

The availability of enthusiastic and well-qualified teachers has been identified, by various studies and reports, as one of the most influencing factors that inspire and influence young peoples' attitudes towards science and mathematics (see Osborne, 2004 for an overview).

It has been suggested that teachers can and do make a huge difference to their pupils' enthusiasm for a subject, as well as directly influencing their achievements. Teachers' subject knowledge and teaching style are vital factors, but it has been suggested that it is their own enthusiasm that captures pupil's interest and motivates them to study a subject. Research carried out by Osborne and Collins in 2001 suggests that *"school science's most valuable resource is a cadre of well-qualified, enthusiastic teachers who are justly remunerated for their skills"* (Osborne and Collins, 2001, p.1).

Although Osborne et al (p. 18) notes several studies that have identified the 'influence of classroom environment' as a significant determinant of attitude (e.g., Haladyna *et al.* 1982; Myers and Fouts 1992; Talton and Simpson, 1987), there does not appear to be any known studies which conclusively or strongly determined whether teachers with backgrounds in science and mathematics have a direct or indirect influence on pupils pursue of STEM subjects at school and beyond (Osborne et al, 2003).

Munro and Elsom (2000) investigated the influence of careers advisors and science teachers on year 9 – 11 pupils' decisions about subjects and courses post 16. They suggested that choices made by pupils at that stage significantly affect the available range of future courses and careers. Two methods were used in the study, firstly a questionnaire was sent out to careers advisors, and secondly six case studies were conducted at particular schools. Their dedicated questionnaire for careers advisors covered their experience, educational and employment background, awareness of science in schools and confidence in discussing science and related subjects with students and teachers. The questionnaire was sent out to career advisors working with year 11 pupils in 7 career service companies and over 150 responses were received. Their objectives were, to identify if the careers advisors had STEM backgrounds; whether they noticed a difference in advising pupils on STEM and other areas of work, and if school science teacher felt they were the best people to advise pupils.

Their study revealed that science teachers, in general, had a major influence in pupils' motivation towards and their enjoyment of science subjects. They found that teachers had a beneficial impact through the engagement of pupils in extra curricula activities, as well as their own methods of teaching. They were found to be influential in providing information about the context of post 16 science courses. However, teachers did not view themselves as a source of information and advice about careers in science and technology. They saw the careers advisors as the primary provider of this information and, as such, did not keep up to date with career information.

Results from case studies of the six schools showed that although enthusiastic and motivated teachers existed in the schools, their ability to enthuse students was limited by time constraints imposed by a heavily content driven national curriculum which hindered participation in extra curriculum activities. Furthermore, health and safety requirements of experimental work and the apparently lower intellectual challenge of GCSE science compared to some humanities subjects were also found to be amongst inhibiting factors.

Furthermore, the study found that pupils who chose not to pursue a science subject were taking that decision based, mainly, on their experience in the classroom. Those pupils who continued with science were doing so because they needed the subject for a particular career of choice or were especially interested in it.

Results of the questionnaires completed by the participating careers advisors revealed that just 10 per cent of them had a STEM degree. Only 5 per cent of year 11 pupils sought advice about science related careers, leading the advisors to voice concerns about the lack of interest in science. Careers advisors were seen to be lacking in regular meetings with science teachers and drew upon experience of those around them with STEM backgrounds to advise pupils on those subjects.

Furthermore, evidence from a more recent study carried out for the Department of Skills and Education in 2006 shows that many science teachers are required to teach sciences outside their specialism which is believed to undermine their confidence, leading them to offer limited and less stimulating experiences. This may, therefore, be a contributing factor to the declining interest of pupils pursuing STEM subjects at secondary and tertiary educational levels, given that previous research in the UK has raised concerns about the difficulties of recruiting and retaining specialist teachers in mathematics and science in schools. This has been most notable in mathematics where a lack of appropriate resources to support teachers in the subject has contributed to a waning in the take up of, and attainment in, post-compulsory school mathematics. Moreover, where individuals do go on to pursue mathematics at tertiary level of education, there is a leakage and a significant migration towards other sectors and careers which require mathematics skills leaving an under-supply of specialist mathematics teachers (Moor, *et al*, 2006).

Sir Roberts Review (2002) identified the shortage in the supply of science and mathematics teachers as one of the deep-seated issues. This has remained to be addressed in order to improve the UK's future supply of high level science and engineering skills.

As a response to concerns raised in the Sir Roberts Review, the Government has announced a package of measures to improve the skills of science teachers. These are stated in the 'Science & Innovation Investment Framework 2004-2014, Next Steps' (P. 43) as follows:

- 'step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers so that by 2014 25 per cent of science teachers have a physics specialism; 31 per cent of science teachers have a chemistry specialism; and the increase in the number of mathematics teachers enables 95 per cent of mathematics lessons in schools to be delivered by a mathematics specialist (compared with 88 per cent currently);

- continue the drive to recruit science graduates into teaching via Employment Based Routes with new incentives to providers of £1,000 per recruit to attract more physics and chemistry teachers; and

- develop and pilot a Continuing Professional Development (CPD) programme, leading to an accredited diploma, to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively'.

As a response to the Government's targets, the Department for Children, Schools, and Families (DCSF) has recently set out a strategy which includes a package of support for teachers which include:

- continuous Professional Development (CPD) through the national network of Science Learning Centres;

- a new accredited training course developed by the Training and Development Agency for Schools for teachers who don't already have a physics or chemistry specialism;

- initial training bursaries of £9,000 for science graduates entering teaching;

- 'Golden Hellos' of £5,000 payable to eligible newly qualified teachers; and

- funding from the Teacher Development Agency (TDA) to support the appointment by schools of a science-specialist Higher Level Teaching Assistant.

However, despite the growing number of CPD and other courses and programmes for teachers, including those set up by the Science and Learning Centres, the Government's own information suggests that recruitment to teacher training courses in 2005-6 fell short of targets by 10 per cent in science and by 18 per cent in maths (BBC, 2008a).

As the latest attempt to tackle the shortage of qualified teachers, the Government is now urging companies to encourage career switching amongst their scientific workforce to go into teaching (BBC, 2008b). A new programme called the 'Transition to Teaching' programme, launched in spring 2008, linking the teacher training agency with employers, aims to encourage science experts to consider teaching as a second career (www.transtoteaching.org).

Furthermore, The Life Long Learning UK (LLUK) has recently introduced a new programme for the further education sector (FE) entitled, 'Catalyst'. The Purpose of the 'Catalyst Programme' is to create new opportunities for training and skills providers to help shape the lifelong learning workforce of the future. Working with the Department for Innovation, Universities and Skills (DIUS), Catalyst has proposed to introduce recruitment schemes to attract graduate-calibre individuals, managers and vocational and technical experts into the further education (FE) sector. It also aims to provide new opportunities for current teachers, tutors and trainers to update their skills in industry.

Catalyst is planned to be delivered through four key areas of activity as outlined in the DfES, (2006b), FE White Paper, 'Raising Skills, Improving Life Chances', namely:

- 'Make a Difference will encourage high-flying graduate-calibre individuals to pursue a management career in the FE sector.

- ✳ Business Talent will help training and skills providers attract talented managers from other sectors and utilise their skills within FE.

- ✳ Business Interchange will give FE staff the chance to work more closely with local businesses and update their practical and vocational skills.

- ✳ Pass on Your Skills will provide opportunities for skilled specialists to move into teaching roles within FE', (source, www.lluk.org.uk).

LLUK aims to work in partnership with employers, learning providers, representative bodies and other FE system organisations to deliver these programmes.

A new report produced for the Royal Society in 2008, entitled, 'A Higher Degree of Concern', highlights a fundamental issue, i.e., the lack of an up-to-date detailed knowledge of the number of UK primary teachers with a maths or science background. Furthermore, it states that the two main sources of data on secondary school science and maths teachers are not reliable enough to represent the national picture (Royal Society, 2008).

The report shows that the shortage of science and maths teachers is worsened by lack of reliable data and statistics. The report suggests that targets set by the Government are, themselves, based on unreliable information, with the teacher shortage likely to be much higher. The report reveals that in the UK there is no accurate estimate of the population of science and mathematics teachers (Royal Society, 2007a). This has been attributed, partly, to the fact that there is no consensus about how a "specialist" science or maths teacher should be defined (Royal Society, 2007; BBC, 2008a). This is an area of urgent attention.

Section 2.2: The Importance of Role Models, Mentors and Ambassadors

Numerous reports and studies (British Council, 2001; Greenfield, 2002; Roberts, 2002; IOP, 2005; Royal Society 2005 and 2006; London Skills Council, 2006) cite or promote the use of role models, mentors and ambassadors as a key source of influencing the minds of young people, particularly amongst the under-represented groups (girls and ethnic minorities). Research conducted as the basis for the development of the Royal Society's Role Model Good Practice Guide, (2005) concludes that although it is not possible to measure the ultimate impact of the role model programme on final career choice, evidence provided in these studies suggests that exposure to role models during the critical junctures, i.e., earlier years of education, has a positive influence on inspiring career choices among young adults (Royal Society, 2005).

The Role Model Study, commissioned by the Royal Society, supported by the National Endowment for Science, Technology and the Arts (NESTA) and funded by the then Department for Education and Skills (DfES), shows that role models can make STEM seem more exciting, interesting and relevant. They can challenge persistent stereotypes particularly of STEM being mainly for boys or super intelligent beings. They can also help teachers add value to their science lessons and help youth group leaders to enrich their activities (Royal Society, 2005).

The survey of over 1,000 scientists carried out as part of the Royal Society study (Hackett, 2004) revealed that 52 per cent had been influenced in their choice of career by a visit to a scientist's or engineer's place of work while at school, and 23 per cent had been influenced by a scientist or engineer visiting their school. Furthermore, 41 per cent of respondents cited that they were not planning to study science or engineering prior to participating in an activity with SET role models, but after the involvement of role models they had considered careers in science. However, 28 per cent of the participants indicated that they had planned to study science or engineering before the participation.

Research into the participation of women, ethnic minorities, and other less represented groups in STEM has consistently revealed that a lack of role models and mentors is perceived to be one of the main underlying cause of the minority status in these fields (Quimby and DeSantis, 2006; Wynarczyk, 2007b).

One of the reasons why there are few female and ethnic minority role models and mentors in STEM may arise from the uncertainty over career progression. Ragins and Cotton (1993) observed that women were less likely to become mentors because they perceived more drawbacks from it compared to men. Their study revealed that women felt unqualified and uncomfortable being a mentor, and they believed that the costs outweighed the benefits. Kram (1983) provides a partial explanation for this by suggesting that individuals who are still struggling to get ahead in their own careers may be more reluctant to share wisdom with junior colleagues because they feel threatened. Previous studies purport that mentoring is more beneficial to women because they may encounter more barriers to their advancement than men (Tharenou, 2005), and are consequently more likely to be concerned with advancing their own careers than the careers of others (Vincent and Seymour, 1995). Therefore, role models and mentors are likely to be individuals who have achieved career success and are satisfied with their own level of achievement. It is, therefore, important to publicise more widely the advantages and rewards associated with being a 'role model' and 'mentor'.

It has been suggested that role models and mentors can personally benefit from their own contribution to role model and mentoring schemes. According to Marshall, mentors have a moral obligation to disseminate the knowledge to future generations so that their protégés don't repeat past mistakes. In doing so, mentors achieve a sense of personal satisfaction and peer recognition. Mentoring programmes enable mentors to engage in creative pursuits that develop their mental acuity by providing them with opportunities for continuous learning. Moreover, mentoring programmes help mentors to reflect on their best practices, which results in mentors setting an example, and thus becoming a role model (Marshall, 2001).

Mentoring and organisational citizenship behaviours are important to workplace behaviour associated with career advancement because protégés offer mentors work assistance, and act as sounding boards for ideas. Moreover, some organisations duly compensate mentors who demonstrate organisational citizenship behaviour through increased salary, promotion, status recognition, and overall performance evaluation. Indeed, over 97 per cent of mentors claimed that being a mentor had enhanced their career (Jandeska and Kraimer, 2005).

However, despite the alleged importance of role models to an individual's career development, there remains scant research on role models in specific careers and in organisations (Gibson, 2004). More importantly, systematic research on role models, particularly female and ethnic minority role models in science, engineering, and technology (SET) is sparse. We do not know of research on enthusiastic and inspiring teachers themselves acting as role models and mentors at their own schools to inspire and encourage their pupils to become the science teachers of tomorrow. If teachers can be seen by pupils as role models and teaching can be seen as a rewarding career, it may encourage more young people to consider teaching as a future career option. This will help to address the shortage of well qualified science and mathematics teachers in the future.

Role Models, Mentoring and Ambassador Schemes

In the UK, there are several networks and organisations which aim to foster the interest and participation of young people in science by providing an avenue to role models, mentors, ambassadors, and networking opportunities. They include, The Royal Society Role Model Study, the Science and Engineering Ambassadors (SEAs) Programme, Computer Clubs for Girls (CC4G), The Vega Science Trust, The British Society of Science, SEMTA, SETNET, SETPOINTS, RCUK's Researchers in Residence Programme.

Most existing role model schemes and initiatives fall into the four categories of:

- Events (usually a visit, event or festival centred around hands on activities)
- Networks (comprised of SET practitioners or university students who visit schools and other groups in their local area on a reasonably regular basis)
- Public campaigns (aimed at the promotion of positive SET role models)
- After school clubs (incorporate visits from SET role models who may be members of network type schemes)

The Science and Discovery Centres, museums, books, internet and media all play a significant role in inspiring children and young people by exposing them to renowned scientists' lives, discoveries and inventions that exist throughout history.

The role model schemes and initiatives, in general, aim to expose young people to accessible role models, i.e., people from a broad range of STEM disciplines and careers at all levels and ages. They include enthusiastic and inspiring people who have achieved, or are pursuing, successful scientific careers and education and have passion for science the role models volunteer to inspire others. The Royal Society's Role Model Schemes, for example, has produced several 'Good Practice Guidance' for schools, teachers and practitioners and one on how to become a role model and what it entails (Royal Society, 2007).

The Royal Society also actively encourages its Fellows to become role models and participate in extra curriculum activities. The Royal Society's website provides a list of the Fellows, together with contact details, and encourages schools to invite Fellows to their Schools. However, the extent to which Schools are aware and engage these Fellows is largely unknown, let alone the assessment of real impact on the greater take up of STEM subjects at schools and beyond.

Ambassadors who are involved in the Science and Engineering Ambassadors (SEAs) Programme are individuals from a wide variety of STEM backgrounds, from all across the UK, who offer their time, enthusiasm and expertise to help schools to inspire young people in STEM. The programme has over 17,500 Ambassadors, with plans to expand this to 18,000 by the end of March 2008. The information about the programme is available from the SEA's website. SEA has also produced a document based on several case studies of its inspiring Ambassadors.

In general, however, there is limited information available about the schools which have made use of role models and ambassadors. Furthermore, there is no evidence to suggest that the engagements of these role models and ambassadors have a real impact on encouraging the greater take up of science subjects at school. As such, we know very little about the level and nature of involvements of these role models and ambassadors. These issues are worthy of investigation.

While it is not possible to measure the ultimate impact of the role model programme on final career choice, it is possible to measure whether the programme or activity took steps towards meeting its aims. This can be done by asking young people about their attitudes towards STEM before and after an event through the use of a questionnaire. A comparison of the subject choices of those involved in role model schemes with a similar group from a previous year may be an effective evaluation tool. For example, SETPOINT West Yorkshire has devised an online evaluation tool called, 'Quiet', to help evaluate events and programmes. The organiser ranks a list of objectives provided by SETNET and adds any others. A cross section of those involved in the event are asked to rate the event and what the participants have learnt. A printout then compares what the event was trying to achieve with what was actually achieved. It also investigates how much progress towards the objectives has been made compared to the cost of the event. This system was used for the first time in 2004. However, it is recognised that it only provides immediate reaction rather than a longitudinal tracking.

There are a limited specific role model programmes relating to ethnic minority groups. The African-Caribbean Network for Science and Technology, for example, runs role model programmes for young Muslims. Within the scheme, parents are always consulted, especially if activities are taking place outside school. In some cases, in response to parents concerns, single sex group activities are carried out and female students, for example, only interact with female role models. The support of parents is regarded as crucial (Royal Society, 2004).

Section 2.3: Science, Design and Technology Laboratories and Equipment

Research carried out by Osborne and Collins in 2000 states that 'school sciences most valuable resource is *not* its equipment or its laboratories but a cadre of *well-qualified, enthusiastic teachers* who are justly remunerated for their skills' (Osborne and Collins, 2000: p.92). Although teachers are the most valuable resource, they need to have access to modern equipment and laboratories to make science lessons more appealing and engaging.

The Roberts Review has identified 'out-of-date' scientific laboratories and equipment as one of the deep seated issues, alongside the shortage of well-qualified teachers, which also needs to be addressed in order to improve the UK's future supply of high science and engineering skills. A study carried out in the USA shows that laboratory experiences, as a part of most USA high school science curricula, have been taken for granted for decades, and they have rarely been carefully examined (Singer, *et al,* 2005). In the UK the impact of the nature and use of laboratories on take up of science subjects also remains a neglected area of research.

Kahle and Meece's paper on gender issues in the classroom in the USA published in 1994 cited two studies that showed teachers who had a high proportion of girls continuing to enrol in high school chemistry and physics used specific teaching practices, which included, laboratory work, discussion groups, quizzed students weekly, stressed creativity and basic skills. They also used numerous printed resources rather than relying solely on one textbook. They had attractive classrooms, decorated with posters and projects, and kept live plants and animals in their laboratories (Kahle and Meece, 1994).

Another USA study carried out by Freedman 2002 investigated the effect of laboratory work on achievement and attitude to physics of grade 9 students, using an intervention and control group. They found that those girls who had taken part in laboratory work intervention improved their science achievement compared with girls who had received traditional teaching with no laboratory component. There was no difference between the achievement of boys and girls in the laboratory group, whereas the achievement of girls in the group that had not undertaken any laboratory work was less than that of boys in that group. The study concluded that laboratory participation was the reason for the higher achievement of the girls.

As Sir Roberts (2002) has commented, science, design and technology laboratories and equipment are vital to pupils' education in science subjects, both through directly educating pupils about areas of science and technology, and in making them become more interested and enthusiastic to continue to study science subjects further. Modern well-equipped laboratories are more likely to influence students' perceptions of science and post-16 choices.

A full assessment of the state of school laboratories in England is not available as data is not collected centrally and there remains a huge gap in the data. Limited data shows that out of date laboratories and equipment are still found in many schools, preventing practical science work being undertaken and damaging the perception of science in the minds of young people. Research commissioned by the Royal Society of Chemistry in 2004, for example, showed that only 35 per cent of the 26,340 secondary school science laboratories in England were graded good or excellent. Of the remainder, 25 per cent were considered either unsafe or unsatisfactory for the teaching of science.

In order to address the shortage and out of date laboratories and equipments, in July 2002, the Royal Society convened a half-day meeting to brainstorm ideas for a policy project aimed at increasing the quality of school science laboratories. Attendees included the Association for Science Education (ASE), the Royal Society of Chemistry, Wellcome Trust, CLEAPSS and Science Year.

Subsequently, in March 2003, the Royal Society agreed with Planet Science to support a project aimed at giving practical advice and materials enabling better planning of new school science laboratories. This resulted in the production of bespoke software, a guidance package and case studies to assist schools and LEAs regarding laboratory design. It was launched at the ASE Annual Meeting in January 2004. The final version was disseminated to all secondary schools, further education colleges and all recipients of the ASE journal Education in Science. The software was highly popular at the ASE Annual Meeting in January 2004 and explicit mention of its usefulness is made in the new *Building Bulletin 80* issued by the DfES. The Software has been designed to encourage communication between science teachers and technicians, and architects and designers. Design ideas can be viewed interactively in 2D and 3D to highlight specific problems that may arise. Documents with guidance for the architects, designers and manufacturers are given along with advice for the teachers and technicians (ASE, 2004).

There exists another scheme run by Plant Science called, the Kit Pot. It has been designed to improve the level of equipment that schools have access to and offers free and reduced cost equipments. The scheme is based on the belief that good equipment is necessary for teaching and learning. The scheme has a regularly updated website and offers a wide range of free resources; from tickets for discovery centres to books and CDs. There is also educational equipment including ideas for lessons, articles from esteemed individuals and organisations and product showcases. For example, there is a resource called an "Introduction to Chemistry" which is aimed at Key Stage 4 pupils and has models to help teach chemical principles. Every maintained school in England has an Intel Play QX3 computer microscope, an interactive white board and access to a variety of software that can be downloaded from the website (http://www.schoolscience.co.uk/kitpot).

In the Science and Innovation Investment Framework, 2004 - 2014, Next Steps, the Government has pledged to improve school accommodation: 'by 2007-08, capital investment in schools will have reached £6.3 billion a year' (HMSO, 2006, p.50). The policy priority is to improve the state of school science accommodation by making school science labs a priority.

Section 2.4: Gender Imbalance in STEM

"From birth, parents often unconsciously treat young girls and boys differently. Children as young as five already have stereotypical beliefs about what constitutes men's and women's work" (British Council, 2001: 3).

Current trends and literature clearly demonstrate a pronounced 'gender imbalance' in the number of females taking science subjects at A-Level, particularly, physics, chemistry and mathematics.

As highlighted earlier, research studies have identified several factors that influence the attitudes towards science in general. Osborne's literature review of factors influencing attitudes has identified gender as one of the most significant factors. Osborne (2007) builds on research by Gardner (1975), Schibeci's (1984) extensive review of the literature, more recent meta-analyses of a range of research studies by Becker (1989), and Weinburgh's (1995) work covering the literature between 1970 and 1991.

Research suggests that prior to the age of ten, children's interest in science is found to be generally high, equally amongst boys and girls. The final years of primary schools form the critical points of decline particularly amongst girls (Murphy & Beggs, 2006; Osborne, 2007). Several reports and literature have attempted to investigate reasons why girls harbour significantly more negative connotations about certain science subjects and careers (Grant, 1995), the societal applications of STEM (Hornig, 1992; Napolitano and Ogunseitan, 1999) and what influence the views and attitudes of boys and girls about science from an early age (Osborne and Collins, 2000).

Girls are also significantly more negative about the physical sciences than boys (Murphy & Whitelegg, 2006; Osborne & Collins, 2001; Osborne et al, 2003). Data collected by the Relevance of Science Education (ROSE) Project (Schreiner & Sjøberg, 2004), using a standard survey administered in over 20 countries, shows that the decline of student interest in school science is an international phenomenon with girls, in the overwhelming majority of countries, liking school science less than their male counterparts.

Girls' participation in physics is particularly low. It has been suggested that young girls expect to find physics difficult. This is due to the nature of the curriculum which is believed not to fit in with their perception of femininity. In the main, it is the stereotypical image of physics that is believed to draw many young men naturally towards it and deters young women from it (Haste, 2004; IoP, 2005).

Osborne and Collins' study on pupils' and parents' views of the school science curriculum found that girls at the end of Key Stage 4 (16 year olds) had a tendency to make more negative comments about physics than their male counterparts. This may suggest that the content of Key Stage 4 physics classes need to incorporate elements that engage the interest of girls. However, when seeking parents' views, it is interesting to note that the parents, in general, expressed that "school science curriculum no longer had any inherent gender bias that was a feature of the separate sciences offered to their own generation", (Osborne and Collins, 2000:p.9).

There is some evidence to suggest that once these views are formed they can be strongly held in adult life. Grant (1995) observed that there was an inverse relationship between the level of perception of a science subject being considered more mathematical (i.e. 'harder') and the rates of participation of women in those sciences. For example, women are less likely to take up and study the "harder" engineering disciplines, computer science and physics compared to the less mathematical sciences of anatomy, biology, physiology and pathology.

Hornig's study on different gender responses to views about science and technology found that women expressed more anxiety than men about science and technology 'taking over the world', displacing jobs, and the motives of private interest in the development of science and technology (Hornig, 1992). To the contrary, men found new scientific and technological discoveries "exciting", supported their advancement, and viewed them as potential solutions to societal problems. Similarly, Napolitano and Ogunseitan's (1999) survey of 111 male and 135 female respondents observed that women had a greater tendency to express disapproval of novel genetically-based procedures compared to men. For example, the study found that 63 per cent of men held a positive view that genetic engineering is a socially beneficial field of scientific research compared with only 48 per cent of females. These observations suggest that there are distinct attitudinal differences between men and women in how they view and engage with science and technology.

There is also concern about the attitudes and participation of girls in mathematics. Although, as stated in section 1, girls tend to have a larger advantage of around 5 percentage points in the science and maths subjects over their male counterparts (DfES, 2007a, 200b), there is a pronounced 'gender imbalance' in the actual number of females taking A-Level in mathematics. As a result, women, in general, enter the workforce lacking the mathematical skills for many research jobs and their education and training leads them towards practice, policy and the humanities leaving hard science, theoretical development and exploration, which require greater mathematical skills, to males (Etzkowitz et al 2000).

Research carried out in the US shows that 'girls and women who opt out of mathematics in high school or soon after prematurely restrict their educational and career options' (Heller & Parsons, 1981; Meece, Wigfield, & Eccles, 1990; Secada, 1989). Mathematics has been identified as the "critical filter", acting as an important gateway to many high-income and high-status careers (Sells, 1980). The USA studies show, in general, that participation of girls and women in mathematics decreases markedly as they progress to higher educational and professional levels (Herzig, 2004). Furthermore, it has been suggested that teachers' gender-biased perceptions of girls' scientific ability, the lack of female role models in science classrooms, and the unequal training of girls as a result of fewer experiences with science activities in the classroom all contribute to lowering the number of women pursuing scientific careers (Steinke, 1997).

The home and school environment influences girls' vision of their role in society but also their degree of assertiveness, experimentation, self-motivated exploration and risk taking - important features in the lives of successful scientists. These factors influence girls' choice of subjects at school (e.g. maths and physics) and their subsequent capabilities and confidence to undertake front-line scientific positions. This is before taking into account other influences, factors and explicit hostility to women in male dominated sectors (Wynarczyk, 2007a).

Because science has been dominated by men for centuries, the culture of scientific inquiry and departments also tends to be predominantly male (Wynarczyk, 2007a). However, it has been argued that traditional images of masculine science may have changed or become less significant in accounting for gender differences in science. There are other factors worthy of further investigation, for example, the opportunity to participate in new non-science subjects, which may be more appealing (e.g. fashion, media and film studies), deterring girls from taking up science subjects.

Etzkowitz *et al* (2000) in discussing the place of women in science and technology (this discussion is limited to the processes by which women achieve final positions as senior academics) sees the process of gender differentiation beginning at a very early age. They suggest that women have no inherent incapability to follow a career in science but that they follow a 'pipeline' process. The process begins in infancy with a large supply of potential scientific workers but as the process of socialising, education and employment takes place the pipeline is found to be leaking at various joints (decision points in life-chances) that results in only a trickle of women eventually emerging to make successful careers in science. Even with the improvements in women's participation in scientific studies in recent years, the number of women reaching the higher positions in science is much lower than expected in the USA and in many other countries.

Etzkowitz *et al* (2000) claim that from an early age:

"....boys and girls develop different gendered images of scientists and what they do." (Etzkowitz *et al,* 2000, p.26).

"In many ways, women are unable to choose to do science: society has already chosen who will do science through its construction of gender roles." (Etzkowitz, *et al,* 2000, p.47).

Concerns about the under-representation of women in STEM have been raised and expressed by researchers, policy makers and practitioners since the seventies. In 1994, the UK Government Committee on Women in SET produced a report called 'The Rising Tide' - A Report on Science, Engineering and Technology (HMSO, 1994). This report provided an overview of the continual 'dropping out' of girls and women at every stage of the SET pipeline. Few women eventually emerge to make successful careers in sciences beyond the 'glass ceiling'.

The Rising Tide Report identified a number of key areas of concern, including, education, training, employment and positions of influence. Since the publication of the report, considerable efforts have been devoted to the development of numerous initiatives, reports and consultation, particularly at national levels. However, even with the slight improvement, the SET education and employment, in general, continues to remain male-dominated.

Since the production of the report research and policy has continued to address the continuous 'dropping out' of girls and women at every stage of the 'leaky pipeline' (e.g., Greenfield, 1994, 2002; Blickenstaff, 2005; Wynarczyk, 2006).

In January 2002, Baroness Susan Greenfield was appointed by the Government to advise on a stronger and more strategic approach to addressing and combating the under-representation of women in SET. Baroness Greenfield's report, SET FAIR, published on 28 November 2002, identified issues and challenges faced by women, and the activities and initiatives available to them. The report identified over 70 initiatives, projects and or organisations dedicated to increasing the participation of women in SET, but concluded that there was little information on their effectiveness. It stated that '*Whilst* *numbers of women studying and working in SET are rising it is unclear how many have been influenced or helped by any of this effort'* (DTI, 2002). The report also stated that with a large number of non-governmental organisations and initiatives also involved in the sector, the process is fragmented and uncoordinated to the extent that policy and initiatives may be unable to reach their full potential.

The report made several concrete recommendations and measures for Government to help to overcome the barriers that prevent women and girls from entering, remaining, returning and progressing beyond the glass ceilings in the SET education and employment pipeline.

The Government responded to the SET Fair report and on 28 April 2003, published 'A Strategy for Women in Science, Engineering and Technology', and has, since, made a firm commitment to remedy the situation. One major outcome of the Strategy is the establishment of the UK Resource Centre (UKRC) for Women in SET, funded from the science budget of the then DTI and now the DIUS. Launched in September 2004, the UKRC aims to provide practical support and help in order to encourage more women to take up a career in SET, including those with a career break (UKRC, 2007; Wynarczyk, 2006, 2007a). However, the activities of the UKRC are predominantly focused on the participation of women in STEM careers and its remit does not include STEM education, particularly at primary and secondary levels.

In the USA, a great deal of attention is focused on the development of specific initiatives to encourage greater retention of young girls in STEM education. Specific examples are given below and in cases where the impact of such schemes has been assessed on STEM uptake this is also presented. This is not an exhaustive review but represents some of the more comprehensive schemes in operation.

The Association for Women in Mathematics is a non-profit organisation dedicated to encouraging women and girls to study and have active careers in the mathematical sciences. The association offers educational resources for teachers and students including: biographies, careers forums, awards and scholarships. The Association for Women in Science is similarly themed and is dedicated to achieving equity and full participation for women and young girls in science, mathematics, engineering and technology. Particularly relevant programs undertaken are "take our daughter to work day" and "women in science day" both carried out at universities, where established female scientists share their experiences and expertise with younger students (http://www.awm-math.org/ http://www.awis.org/index.html).

The Young Women in Science Program which began in 1999 operates at the University of Kentucky Chandler Medical Centre. It encourages young women from rural Appalachia to pursue careers in drug abuse research or related scientific fields. Participants receive training, education and mentoring over a three year period and take part in intensive three week sessions each summer and five weekend sessions during the school year. The girls also receive mentoring from female research and community leaders and at the end of the program they receive a stipend and college scholarship. The progress of all girls who complete the programme for at least 5 years to assess the real impact of program on subsequent education and career paths. Following the deemed success of the scheme a similar project is being carried out for 7th grade students (Bonck, 2002).

In the USA, there are several other programmes that can be identified as examples of good practice and are worthy of further examination. These include:

- 'EQUALS'. This programme aims to increase access and equity in mathematics for all students, particularly girls and under-represented groups. The scheme presents innovative ways of learning and thinking about mathematics that help to build success for all students and offers resources and equipments for teachers and students. **(**http://www.lawrencehallofscience.org/equals**).**
- Engineer Girl is a website dedicated to offering information about women in engineering. It is part of a national academy of engineering program to bring attention to the opportunities engineering represents for women and girls. Fun facts, great achievements, essay contests and career information are offered (http://www.engineergirl.org).
- Sally Ride Science Club is an organisation for girls who are interested in STEM. It is open to upper elementary and middle school girls across the USA. The club enables girls to consult with experts and role models, exchange ideas, collaborate with peers, and embark a vast array of online and off-line activities (http://www.sallyridescience.com/).
- Girl Start is a non profit organisation created to empower girls to excel in STEM. A variety of educational resources are available for middle school girls through after-school programs related to hands on exploration of STEM, Saturday and summer camps are also available. In common with the Association for Women in Science is the "take a girl to college for a day" scheme. It is aimed at underprivileged 5th – 8th grade girls from Austin area schools which have a high ethnic minority and low income student population. The girls spend the day alongside a current university student and participate in campus tours and STEM demonstrations. In 2004 survey responses showed that Club Girl Start participants were more positive and enthusiastic about their own futures in STEM. Interest in STEM careers rose from 70 percent to 78 percent and confidence in "being good" at a STEM career increased from 76 percent to 84 percent (National Academy of Engineering, http://www.girlstart.org/index.asp).

Evidence presented by the Association for Women in Science indicates the highlighted schemes are resulting in an increase in the take up of STEM subjects. Women as a percentage of all bachelor's recipients for physical science between 2000 – 2004 has increased from 41.7 – 42.1 percent, for engineering it is 20.1 – 20.5 percent and for biological and agricultural sciences a rise from 57.3 – 60.1 percent is seen (Data source: tabulated by National Science Foundation/Division of Science Resources Statistics; data from Department of Education/National Centre for Education Statistics: Integrated Postsecondary Education Data System Completions Survey).

In contrast to the USA, in the UK only limited numbers of initiatives and measures have been developed by the government and non-government organisations and bodies that specifically focus on encouraging greater participation of girls in STEM education (see Annex 1, pp. 1-5) for a list and a brief description of some specific initiatives for girls identified through the course of this Research Synthesis).

The UK specific initiatives for girls include:

- The Computer Clubs for Girls, an out-of-school club that provides a range of tailored e-learning activities for girls aged 10 - 14 years. It was created by e-skills UK, a not-for profit employer led organisation licensed by the government as the sector skills council for IT and telecommunications. It is currently funded by the Department for Children Schools and Families (DCSF). The initiative was set up following the recommendations made by the Mapping Review 2004

- Let's Talk is a web based resource for schoolgirls in the UK who are interested in Science, Engineering, Construction or Technology as a career choice. It contains information about careers, events and educational resources for teachers (http://www.letstalkset.org.uk).

- The WISE Outlook programme is a three-day programme run at local colleges, enabling year 9 girls (age 13/14) to experience engineering first-hand. The girls take part in hands-on engineering projects, designing and making something for themselves, work in teams to develop presentational skills, talk to women students and staff from technical colleges and meet women engineers to talk about their work and careers. WISE also runs Insight, which is a course for young women studying in the sixth form or on Scottish Highers who are interested in becoming an engineer. Girls get to spend a week at university, staying in student accommodation and meeting others with similar interests. Girls have the opportunity to find out about different fields of engineering, spend a day with an engineering company and meet other women who have studied and are making successful careers in engineering. The WISE annual awards are given in recognition of companies and individuals who have actively addressed the issue of promoting science and engineering to young girls and women, and who have supported the aims of WISE.

Section 3: Regional Disparities in STEM Trends at the Primary and Secondary Education Levels

Current research, policy and government reports on STEM trends focus, mainly, on the participation of boys and girls and, in more recent years, the ethnic minorities, as recommend by Sir Roberts Review. In comparison, very little attention is paid to demographic issues. Sir Roberts Review, using STEM data in 1999, considered regional differences but concluded that pupil choices of A-Levels between regions did not vary greatly although a greater proportion of students in the London region seemed to choose mathematics and chemistry than in other regions. It is disappointing that the Sir Roberts Review did not fully investigate regional differences in terms of the level of take up and performance in STEM subjects in the light of the causes of regional disparities (e.g., socio economic factors). As a result, demographic issues remain a neglected area of research and policy (Roberts, 2002).

A recent mapping exercise carried out on behalf of the UK Resource Centre for Women (UKRC) in SET revealed that in 2005/06 the achievements in core STEM subjects at primary and secondary levels varied across the English regions, Scotland and Wales. The lowest performing region was Yorkshire and Humber particularly for Physics, Double Award Science and Mathematics. In the same year, the achievements of pupils' in Scotland and Wales were below UK national average in STEM subjects (Wynarczyk, 2008).

STEM subjects, in terms of level of participation, attainment and achievement amongst pupils at primary and secondary education located in different regions of England, Scotland and Wales have not been the subject of a comprehensive investigation in 'its own right'.

It is imperative that any future investigation of this kind is undertaken in the light of the socio-economic and socio-demographic factors in terms of, for example: educational attainment, teenage conception rates, GDP, unemployment rates, availability of skilled labour, availability of highly skilled labour and scientific workforce, scientific and R&D activities, managerial capacity, infrastructure, specific initiatives (e.g., the Science Cities), variations in total entrepreneurial activities (by female, male, ethnicity, etc).

These are underlying factors that could affect the supply and demand and influence the nature and effectiveness of Government policy.

It has been recognised by research and policy, that the economic gaps between different regions of the UK have created imbalances in several key economic and social areas, including, standards of living, educational attainment, distortions in the national labour market especially in the availability of highly skilled workers, the scientific workforce and professionals, as well as weaknesses in R&D and business performance. All UK regions, through their Regional Development Agencies, universities and other bodies, recognise the importance of exploiting science and technology. However, as stated in the Governments' Science and Innovation Investment Framework 2004-2014, 'discrepancies between the science and innovation performance of different regions remain large, with total public and private investment in R&D in the high performing region almost 15 times higher than in the lowest performing region', (p.20).

Furthermore, there is only limited academic research that has identified environment, culture and social class amongst factors influencing the take up of STEM subject at school (see for example, Osborne et al, 2003; DfES, 2007a). The representation of men and women as science and technology professionals vary across the regions of the UK and to the disadvantage of less favoured regions such as the North East of England. A recent empirical survey of scientific-based SMEs carried out by Wynarczyk in 2006, as part of the ESRC Science in Society programme, demonstrates that women, compared with their male counterparts, are seriously under-represented in the scientific labour market, particularly in R&D and more so in the North East of England, a region with low innovation and R&D intensity (Wynarczyk, 2007a). Currently there is no evidence of how STEM trends, activities and policies are aligned to such important and underlying factor as these have not been investigated.

Regional economic and social differences could obstruct the implementation of national agenda, policy and priorities. Given the extensive regional disparities within the UK, it is unlikely that a 'one size fits all' policy to encourage greater take up of science subjects at schools and beyond will be, equally, effective across all regions and parts of the UK. In addition, in regions that have suffered economic decline for extended periods of time, there is a need to implement programmes specifically aimed at raising not only the profile of STEM within schools, but also the aspirations of those who are likely to study them. The supply of a diverse STEM labour market, that is representative of society as a whole will not be achieved through high quality teaching alone. It should be supplemented by the promotion of initiatives aimed at combating underlying socio-economic problems which may be more prevalent in some regions and areas than in others.

Furthermore, it is not clear how STEM initiatives are linked to the widening participation agenda, and the integral part of the remit of RDAs to address issues of social inclusion in economic regeneration for their respective regions. It is not clear whether these initiatives have any provisions to engage the socially disadvantaged, particularly groups of individuals lacking skill-sets that are not aligned to the demands of the region, to become inclusive contributors to STEM and allied education and occupations. These issues are worthy of further policy and research attention and need to be explored further.

However, this Research Synthesis Report acknowledges that SETPOINTs have responsibility for an assigned area, which controls the number of schools and colleges they work with, ensuring the highest quality of service and a more personal and efficient channel of communication. This also enables them to respond to specific local and regional needs, whilst maintaining focus and ensuring alignment with national curriculum changes and requirements (see Annex 1, p. 9, for an overview of SETPOINTS activities).

Section 4: An Overview of STEM Initiatives and Interventions

Section 4.1: An Overview of STEM Organisations, Bodies, Initiatives and Schemes

In the UK, there has been a considerable effort devoted by the government, and non-government organisations in the public and private sectors, to the development of new and emerging: qualifications, initiatives, academics, special schools, centres, web-sites, virtual courses, etc., aimed at promoting STEM education to remedy the current unacceptable level of participation in STEM subjects by actively engaging young people in the practical applications of STEM, outside the traditional methods of teaching.

The origin of the first association aimed at promoting STEM can be traced back to 1900 when a letter written by four science masters from Eton College proposing a conference for Science Masters in Public Schools to highlight the need for some form of action for *"emphasising the value of Science as a means of education".* This led to the formation of the Association of Public School Science Masters in January 1901 and, subsequently, initiated the formation of the ASE, the UK's largest professional association for teachers of science which was formed in 1963 as the merger of the Science Master's Association and the Association of Women Science Teachers (www.ase.org.uk)

During 1960s a number of other initiatives were evolved, including the Nuffield Junior Science Teaching project (1964-66) originally targeting 7-13 year olds and, subsequently, extending its activities to include younger children. The general educational 'philosophy' of this project was based on encouraging children's natural curiosity and love of asking questions in order to address the lack of development of science in primary school (Murphy & Beggs, 2005).

However, in more recent years the number of STEM initiatives and measures has mushroomed. New initiatives and schemes are emerging continuously at national, regional and local levels to encourage greater take up of science and mathematics subjects.

There are a number of major government, non-government and charitable organisations, bodies, institutes, HEIs, and foundations in the public and private sectors that, either solely as part of their responsibilities or voluntarily, strive to promote science and innovation amongst young people at schools, through the development of numerous initiatives, measures, schemes and web-based resources. These include, DCSF, SETPOINTS, British Council Science, Royal Society, Science Institutes (e.g., Chemistry, Physics, Engineering), National Endowment for Science, Technology and Art (NESTA), Engineering and Technology Board (ETB), Wellcome Trust, Gatsby Foundation, Science and Discovery Centres (SDCs), the Science and Learning Centres, and Science City Initiatives to name but a few (see Annex 1 for an overview of some of these organisations and initiatives).

However, there is a lack of readily available and easily accessible information about these organisations and their remits with regards to STEM education at the primary and secondary education levels. These organisations have their own websites and although some tend to commission research, there is no published report about their own activities. Consequently, we know very little about their contrition and real impact on increasing the take up of science subjects. We do not know how they relate to each other, let alone their links to initiatives covering other parts of the STEM pipeline. There is also confusion as how their activities are co-ordinated. Currently, there is no accessible directory or user guide that brings together information about these organisations that aim to promote their initiatives and schemes in order to encourage greater take up. However, the STEM Directories project is a new initiative which seeks to achieve this goal of one comprehensive location for all initiatives (http://www.stemdirectories.org.uk/).

In 2004, a STEM Mapping Review was initiated, resulting from concerns raised by the Government over the continuous decline in demand for university places in STEM and a perceived lack of supply of graduates and qualified technicians in engineering and related professions. The review revealed over 470 STEM initiatives run by the then DfES, DTI and external agencies. Following an examination of these initiatives, the Review concluded that a vast majority of these initiatives are targeted at primary and secondary sectors compared with activity in the Further Education (FE), Higher Education (HE) and other sectors. The review also showed that post 16 activities in teaching and learning is mainly focused on science and mathematics as two priority areas (DfES, 2004).

The STEM Mapping Review 2004 highlighted the lack of coherence in the 'plethora' of existing initiatives and revealed the lack of readily available evaluation. The result of the overall mapping exercise showed that less than 50 per cent of initiatives had some methods of evaluation in place. It was revealed that when the evaluation was carried out, it generally did not incorporate elements of supply and demand and as such makes it difficult to assess and measure the real impact on improving the take up of STEM subjects and whether the supply of STEM graduates is being addressed, these issues still remain to be tackled. The review also showed potential overlaps, many initiatives appear to be providing similar types of support.

The Review identified a number of policy gaps such as lack of specific initiatives targeted at encouraging women, girls and ethnic minorities into STEM. It also highlighted the need for better links across schools, FE, HE and employers in order to ensure that a transition is made across the educational stages of the STEM pipeline (Key Stage education to degree level).

In addition, the Mapping Review highlighted the existence of numerous local initiatives with small scale funding which may have a localised impact on raising attainment and improving the quality of teaching. These are demonstrated in the Excellence in Cities (EiCs) and Education Action Zone (EAZs) programmes. The Review concluded that these programmes link and mesh together well with regard to delivery and support of the national strategies. The Review commented that these initiatives may make an impact locally, but questioned whether they have any major impacts in achieving DfES/Government objectives. The Review emphasised the importance of measuring the real impact and added value of STEM initiatives, these issues still remain to be assessed.

As a response to the long term strategy set out in the Science and Innovation Investment Framework 2004 – 2014 and the recommendations made in the Mapping

Review 2004, the STEM Cross-cutting Programme, managed jointly by the then DfES and DTI, was set up in 2006 with the purpose of examining the range of existing initiatives and interventions that support the challenges set in the Framework and to explore the ways of enhancing the effectiveness of Government STEM funding in two areas:

- the flow of qualified people into the STEM; and
- STEM literacy in the population.

The STEM Cross-cutting Programme (2006) examined around 200 initiatives and analysed over 70 of them in detail. These were chosen from the 470 initiatives identified in the original STEM Mapping Review 2004 on the basis that they were government funded, substantial in scale, and were on-going as opposed to one-off and short term initiatives. The networks which delivered STEM initiatives directly to learners and learners providers were also examined. In addition, initial views were sought from a small sample of science and mathematics teachers and head teachers, some partner organisations, societies and professional institutions on the current initiatives and their suggestions for the future (HSMO, 2006).

The STEM Cross-cutting Programme (2006) concludes that there are far too many schemes and initiatives supporting STEM, mainly directed at school-age students, each of which with its own overheads. While many of them are of high quality, despite recommendations made by the Mapping Review 2004, they continue to remain mostly uncoordinated and largely unevaluated (HSMO, 2006). The STEM Reviews, 2004 and 2006 also pointed out to the potential overlaps, with many initiatives providing similar types of support.

Access to, and information about, initiatives are key factors in their take-up by learning providers and learners. With a large number of non-governmental organisations and initiatives also involved in the sector, the process is fragmented, uncoordinated and confusing to the extent that policy initiatives may be unable to reach their full potential.

The STEM Cross-cutting Programme (2006) highlights the need to rationalise those initiatives supported by the Government and build on the best ones. It has recommend that instead of increasing the STEM budgets to support existing and new initiatives, by focusing on only the best initiatives, a much better result can be achieved for the same amount of money. The STEM Cross-cutting Programme (2006) has made a number of proposals aimed at working towards a vision to ensure that 'STEM support is delivered in the most effective way to every school, college, learning provider and learner'. These include:

- 'no more than ten national schemes of STEM support for schools (excluding national teacher supply measures) that should receive national funding and endorsement; and on how particular existing schemes and funding streams should be rationalised to fit within this simpler framework, building on those which can contribute most to achieving our objectives at national level;

- the introduction of standard evaluation systems across DfES and DTI(DIUS) for future evaluation of STEM initiatives which incorporate longitudinal evaluation and tracking, particularly on impact on progression to studying STEM at post-16 and in higher education, and which would support the effective use of STEM funding; and

- greater alignment of different providers' activities in support of the priorities set out in the Science and Innovation Investment Framework, 2004 2014, Next Steps and some rationalisation of funding streams to support fewer, higher impact activities and reduce complexity for schools and colleges' (p.7).

As a response to the recommendations made by the Review 2006, a specialist group, the STEM Advisory Forum, was established in March 2007 to help formulate Government education policy and make STEM subjects more attractive to young people. The Forum provides an opportunity for all those interested in the teaching and learning of science, technology, engineering and mathematics to contribute their views on the STEM agenda. The views expressed on the website are used to help inform the Department for Children, Schools and Families (DCSF) and the Department for Innovation, Universities and Skills (DIUS) in taking forward the Government's STEM agenda **(**www.stemforum.org**).** The extent to which teachers and other groups are aware of the Forum and its activities and express their views is not known.

Section 4.1.1: Level of Take up Of Stem Initiatives: Examples of Good Practice

STEM initiatives, measures and schemes, in aggregate, form the major components of STEM activity and Government expenditure. They have been set up to address the serious concerns over downward trends in STEM and help to ensure a better transition from interest at GCSE level to an interest at A-Level, higher education and beyond by focusing on extra curricula activities, deemed to be vitally important, particularly in recruiting more participants from underrepresented segments of the population, such as women and minorities (Roberts, 2002).

DCSF and DIUS support different initiatives which aim to motivate young people:

- Science and Engineering Clubs at schools - DCSF currently funds 250 clubs across the country with this number expected to double in 2008;
- DCSF offers new careers advice for young people studying science;
- DCSF as a multi-media communications campaign aimed at young people, parents and teachers to encourage more students to continue studying science post-16;
- DIUS supports National Science and Engineering Week – held every year in March.
- DIUS supports competitions such as the BA Crest Awards and Young Engineer of the Year Award.
- STEMNET (Science, Technology, Engineering and Mathematics Network) funded by DIUS, through its national and regional networks of partner organisations acting as local SETPOINTs, STEMNET co-ordinates a variety of programmes which aim to enhance and enrich the STEM curriculum in schools and colleges, including the Science and Engineering Ambassadors (SEAs) programme.

Whilst STEM's education budget, initiatives and schemes continue to increase in terms of numbers and activities, despite the recommendations made by the Mapping Review 2006, their real impact on improving the take up, performance and achievement in STEM subjects has not been investigated and, as such, their real contribution to STEM education may be undermined. This is a highly neglected area of research and policy. It may be the case that the initiatives generally manage to reach their annual targets, in terms of number of participants (schools, teachers and pupils) and spend the allocated funding. This may be sufficient to qualify them for subsequent funding.

Limited studies, evidence and evaluation of STEM initiatives, grants and schemes that currently exist are, mainly, based on views expressed and comments made by teachers and pupils who have participated in their initiatives and schemes as opposed to any serious attempts to measure and demonstrate the real impact on take up and achievements. The following section provides an overview of some these studies.

A recent study by Lindahl's (2007) of 70 pupils in grades 5 to 9 suggested that positive experiences with science were associated with an increased likelihood of their engagement with science in later life and, conversely, loss of interest in science at an early age decreases their likelihood of re-engaging with science in later life.

The main findings of a recent scoping study carried out for the Wellcome Trust which, amongst other objectives, evaluated the impact of the types of science initiatives already taking place in UK primary schools. It was based on the responses of 300 teachers across the UK to a telephone survey and focus groups with groups of teachers which took place in England, Northern Ireland, Scotland and Wales (Murphy & Beggs, 2006). The study also included the evaluation of HEI primary science initiatives indicated that most initiatives reviewed addressed the following areas:

- Increasing teachers' confidence to teach science
- Promoting scientific investigation in the classroom
- Increasing children's' enjoyment of science
- Improving pupil attainment in science
- Improving continuity between Key Stage 2 and Key Stage 3 science

The study concluded that whilst many of the initiatives reviewed undoubtedly had a significant impact on children and teachers in the project schools, their impact on the school population as a whole was not nearly as high. The study revealed that the largest number of initiatives in primary schools appeared to be aimed at increasing teachers' confidence in science learning and teaching. However, it is not clear from the evidence provided whether or not improvement of teachers' confidence is translated into greater number of participants, better results and achievements in STEM subjects beyond the primary stage.

A recent evaluation of the Einstein Year 2005 Initiative carried out by Peters *et a*l in 2006 built upon a questionnaire-based study of attitudes towards science and scientists among 11-14 year olds in the UK and Ireland. The study revealed that with regards to attitudinal change towards physics, young people who stated that they had participated in Einstein Year events showed a small but consistent increase in interest over non-participants. No significant changes were found in participants opinions about the impact of science and technology on society or about their attitudes to scientists and their work (Peters *et al,* 2006).

As the Mapping Review 2004 has stated, access to, and information about, initiatives are key factors in their take-up by learning providers and learners. Evidence provided in the

Review 2004 also highlighted that there is paucity in the knowledge about their nature and level of activities, take up, added value and impact due to lack of evaluation and a focal point of co-ordination.

It is not clear how these initiatives are linked to the widening participation agenda, an integral part of the remit of RDAs to address issues of social inclusion in economic regeneration for their respective regions. It is not clear whether these initiatives have any provisions to engage the socially disadvantaged, particularly groups of individuals lacking skill-sets that are not aligned the demands of the region, to become inclusive contributors to SET and allied occupations.

The connectivity technologies have provided a significant opportunity for these initiatives to set up their own dedicated websites which are used as the main engine for disseminating information. Due to the vast numbers of initiatives, as well as other web-based resources, it is not easy to access and source information about appropriate initiatives which may affect both demand and supply side factors. This is a criticism that is often made against government-sponsored initiatives in any area of the economy and it is clearly something that needs to be addressed.

This Research Synthesis has identified a number of documents that have attempted to provide information about some of the key initiatives. The Royal Society, for example, has produced a document entitled 'Money, Money: Funding Opportunity for Schools' (available on the Royal Society's Website (http://royalsociety.org), which contains information about some major schemes such as, Partnership Grants, Gatsby Teacher Fellowship Programme, PPARC (now STFC) and the Institute of Physics School Grants Scheme. The original Mapping Review 2004 has provided a list of initiatives by different categories as annexes to its report. The Wellcome Trust scoping study report contains brief descriptions about a number of initiatives (DfES, 2004). Shape the Future has recently produced a brochure which includes information about some 70 schemes, but mainly for the engineering sector (www.raeng.org.uk).

Only a small proportion of STEM initiatives and schemes provide contact details of participating schools, teachers and pupils. Few initiatives and schemes provide case studies or success stories of participating schools, which tend to echo the participants' positive views and comments, publicised via their websites and newsletters.

Presently, there is no concrete evidence to show whether or not there is a positive link between the improvement in the take up of and higher achievement in STEM subjects and participation in extra curricula activities. Assessing the real impact requires some rigorous statistical tests linked to annual GCSE and AS/A Level results which are available via LEAs. Such studies require comparisons of performance ‘before and after’ participations in innovative initiatives and practices (STEM initiatives and schemes). In order to asses the real impact it is also imperative to compare and contrast the level of take up and performance of STEM subjects between a sample of schools that actively participate in STEM initiatives and extra curriculum activities and a sample of non-participating schools. It is also important to examine the characteristics of high performing schools and assess the extent to which they participate in STEM initiatives and extra curriculum activities. It is only through such studies that we will be able to assess the real impact and effectiveness of STEM.

However, despite the abovementioned limitations, it has been possible for the purpose of this Research Synthesis, to assemble a database of some schools and colleges that have participated in a number of key STEM initiatives and schemes and gather some additional information, such as location (city and region), and type (e.g., mixed, single sex and special schools), as well as the contact details of teachers who have taken the leading role in the development of projects and applications. A great deal of time and effort has been put into the creation of this database. This database could potentially provide an invaluable source and basis for a follow up study to assess and examine the real impact of STEM initiatives and schemes on the take up of and performance in STEM subjects.

The following section provides an overview of some initiatives and analysis of their case studies that may be classed as examples of ‘good practice’. Through this exercise it has been possible to identify a number of schools which have developed and delivered innovative measures and projects funded and supported by these initiatives and schemes.

Section 4.1.2: Royal Society Partnership Grants

The Royal Society aims to promote education in the sciences through its Partnership Grants. The scheme offers grants of up to £3,000 to fund projects carried out by primary and secondary school pupils (5 – 18 year olds) in collaboration with practicing scientists and engineers. The partnership benefits all involved. Pupils gain experience within the field of scientific investigation and get a snapshot of what a career in STEM may involve. Teachers are able to increase their scientific knowledge and the scientists and engineers can develop their communication skills and engage with younger minds (see Annex1, p. 11-23).

An overview of the scheme reveals that at the primary level:

* Around 261 Partnership Grants were awarded to primary schools since 2001.

* The highest proportion of grants was allocated to the South East of England (42) and the East of England (35).

* Whist there are many schools that remain unaware or unwilling to participate in the scheme, there are several schools which have managed to successfully obtain more than one Partnership Grants. These include, Herries School, Maidenhead (5 grants); 3 grants awarded to Pulford Church of England, Bedfordshire (3 grants), Deeplish Primary School, Rochdale, Lancashire (3 grants), and Eden Primary School, Carrickfergus, County Antrim (3 grants).

At the secondary level:

* Around 212 Partnership Grants were awarded to secondary schools from 2001.

* The South West of England (40) and South East of England (38) received the most Partnership Grants.

* Some 20 schools obtained more than one grant, accounting for around one quarter of all grants awarded to secondary schools. Examples of multi-awards schools include, Denefield School, Reading (4 grants), Deer Park School, Cirencester (4 grants); Burnham Upper School, Slough (3 grants), and Bedlingtonshire Community High School, Northumberland (3 grants).

The Royal Society produces collections of case studies of participating schools, which can be downloaded from the Royal Society Partnership Grants website (http://royalsociety.org). Case studies provide a good regional coverage. In general, they provide details of participating schools and their project partners, numbers of children and their year, the total allocated grant, title and nature of the programme and activities, as well as some views expressed by the participating scientists, teachers and pupils. These case studies are informative and help to identify examples of good practice.

There are a number of schools which have been awarded Partnership Grants to repeat their initial successful project in consecutive years. It is apparent that once a school has identified and carried out a successful scheme, the Royal Society has the confidence to back it again. Deeplish Primary School, Rochdale, Lancashire, for example, has received funding twice for a project where pupils, specifically those from an Asian background, investigated what it means to be healthy. In collaboration with the Department of Physics at the University of Manchester, they used data logging equipment bought with their grant and linked it to computers to monitor heartbeats before and after physical exercise.

The Royal Society (RS) highly recommends new applicants to consult successful projects and case studies which are on the RS website to generate ideas for their projects and increase the chances of making a successful application. It also encourages participating schools to enter other competitions such as the Rolls Royce Science Prize.

Examples of good practice from the Partnership Grants identified through the course of this Research Synthesis include:

- Projects that have connections to the real world and, therefore, allow pupils to relate science to their everyday lives. For example, Larmenier and Sacred Heart Roman Catholic School, Hammersmith, London, investigated microorganisms in the environment. They used agar plates to explain the need for hand washing to remove unseen microorganisms.

- Hands on activities and offsite visits are important in engaging and increasing enthusiasm of pupils. Almost in all case studies provided by the Partnership Grants, pupils were either involved in demonstrations in the classroom or at the scientists place of work. Schools visited a variety of places from the Royal Botanical Gardens, Kew (Writhlington School, Radstock, Somerset) to the Natural History Museum (La Sainte Union Catholic Secondary School, Hampstead, London).

- Schemes that are very successful may result in their practices used by or shared with other schools. Morecombe High School, Morecambe, Lancashire, and the University of Lancaster hope, for example, plan to share their good practices learned and ideas from their project "what have fruitflies ever done for us" with other schools in the area through the biology tutors discussion network at the University of Central Lancashire.

The results of the case studies show that one particularly prosperous Partnership Grants has actually resulted in the introduction of a new theme to the Key Stage 3 curriculum. Pupils at Writhlington School, Radstock, Somerset, were involved in a scientific investigation of tropical orchids and explored how native Bee Orchids raised from seed could be reintroduced into places where their populations have been damaged. A 'Bee Orchid theme' is now taught in the school as part of the formal curriculum.

The case studies highlight the subsequent effects the grants have on the pupils. Participants often appear in school and university newsletters and websites, local press, LEA's bulletin, educational journals and at international, national and regional conferences. Many of the projects carried out are very well received within the wider science community, some receive other STEM awards. Ermysted's Grammar School, Skipton, North Yorkshire, for example, exhibited their project "fabrication of gold nanowires" at a national pupil conference and produced a display for the Association for Science Education Annual Meeting. Roundwood Park School, Harpenden, Hertfordshire was awarded a Silver Crest Award for their work on "measurement of ascorbic acid in plants", following the successful completion of their Partnership Grants.

There are several other schemes and resources are available to scientists, teachers and pupils from the Royal Society including for example, Acclaim Initiative, Volcano Island Video, Summer Exhibitions, Role Models Initiative and Science Community Partnership supporting Education (SCORE). (See Annex 1 for more information).

Section 4.1.3: The Chemistry at Work Scheme

The Royal Society of Chemistry's (RSC) 'Chemistry at Work' initiative aims to promote chemical sciences to young people and explain the variety of work undertaken by chemists. This is achieved through events around the country, highlighting the positive image of chemistry as a rewarding and wealth creating profession. The RSC provides financial support to a maximum of £550 per day. The scheme has a national coordinator who provides support and organises training schemes for participants. The events last between 1-3 days and are held in a variety of locations targeting 13-16 year olds. The events include hands on activities and presentations. Organisers include, employers, SETPOINTS, universities, college and school chemistry departments, RSC local sections and individuals.

Benefits are wide ranging, the students are able to get first hand experience of chemistry in the real world from those people who are actually involved, teachers update their knowledge and make contacts with local industry, and the companies are able to engage young minds and raise their profile with those who they may one day employ. The successful grant applications are from those schools and institutions that arrange events which have plenty of hands on demonstrations and those that can show how chemistry is linked to the real world. The Chemistry at Work scheme also encourages successful participating schools to take part in other initiatives. Challney High School, Bedfordshire, who have obtained grants for 2 separate events, for example, have also received a STEM Access Grant.

Although there is no direct overall quantitative evidence, feed back at individual events is generally appear to be positive (from students, teachers, presenters and organisers).

The RSC website provides a list of the previous events, including details of host schools and colleges (November 2006 – present, with some extra case studies from earlier years), as well as some of the forthcoming events. The website provides specific information on 59 events – 10 of which were held by non academic hosts. Scotland held 3 events, Ireland 2 events and Wales 1 event. Hosts include; primary and secondary schools, colleges and universities.

For the purpose of this Research Synthesis the events between November 2006 to November 2007 were analysed. A summary of the results are provided below (for a full analysis see Annex1, pp.23-29):

- Around 50 events were held at academic venues. Over half of the academic hosts (59%) are secondary schools with primary schools contributing just (5%).
- All of the secondary host schools are state schools, the majority of which were mixed. 45 per cent of secondary schools have speciality science status.
- The regions hosting the highest proportion of events are, East of England (9), the South East (7) and Yorkshire and the Humber (6).
- There are 4 places which have hosted multiple events, 2 events held at Challney High School, Bedfordshire; 3 events held at University of York, North Yorkshire; 2 events held at Blessed Hugh Faringdon Catholic School, Berkshire; and 2 events held at Peers School, Oxfordshire.

Section 4.1.4: STEM Access Grants

STEM Access Grants are part of the STEMNET (Science, Technology, Engineering and Mathematics Network) project. Schools bid for up to £10 000 per year to engage their pupils especially black and minority ethnic (BME) pupils, particularly those of Caribbean, Pakistani and Bangladeshi origin, in STEM activities. In order to receive a STEM Access Grant the project must fulfil certain criteria, as outlined on the STEMNET website, i.e., at least 50 per cent of the pupils taking part in the project should be from BME and the activities undertaken must support the Work Related Learning Agenda at Key Stages 3 and 4, and/or Applied GCSEs, demonstrate clear STEM curriculum links, utilise existing STEM schemes or initiatives, demonstrate links to the world of work, involve appropriate STEM role models and demonstrate development opportunities for teachers (http://www.stemnet.org.uk).

The scheme has been running since 2006 and a list is provided on its dedicated website for the 46 schools that obtained grants in 2006 - 2007 and those that have been successful for 2007 – 2008 (see Annex 1, pp.29-34). An analysis of these schools shows that:

- A relatively higher proportion of grants were allocated to London (15), followed by the North West (11).
- At a county level the highest number of grants are allocated to Greater London (15) followed by Lancashire (10).
- No STEM Access Grants has been awarded to independent schools or tertiary education organisations.
- No school has been awarded more than one STEM Access Grant.
- Approximately 15 per cent of the schools have science specialist status.

The grants that are supported share the best practice characteristics of:

- The involvement of science and engineering ambassadors or other role models in the projects.

The Science and Engineering Ambassadors (AES) are involved in almost every supported STEM Access Grant. Their role is to highlight how science is related to real life and to provide examples of possible career paths through presentations at events such as careers days. The Bulmershe School, Woodley, Berkshire, for example, forged strong links with the Imaad group of mentors through their STEM Access Grant. The group was a lead partner in applying for the grant initially and it has paid for the training of more mentors. The mentors are ideally from the same ethnic background as the mentee and they are encouraged to meet with their mentees every month and take an interest in their individual learning. *"It is far too early to judge achievements by exam results, but it is quite clear that students taking part in activities funded by STEM are more focused, stimulated, and engaged,"* (Jawwad Raja of Imaad group of mentors, http://www.imaad.org/projects_enabler.htm**).**

- Off site visits to organisations that schools have established links with.

The STEM Access Grants awarded to Challeny High School, Luton, Bedfordshire, for example, enabled pupils to go on science related trips. This is believed to have increased the number of expected applied science students grade A* - C from 37 per cent in 2005 to 60 per cent in 2006. Links were forged with the local Centre of Excellence for Science supporting sustainable land management, Rothamsted Research, (http://www.rothamsted.ac.uk/). Students visited the centre to get practical experience of a wide range of science career options. *"I can see the difference the trips are making every day. Attention in lessons has improved dramatically, and lots more students are getting their work in on time, for example"* (Bob Mackenzie, Assistant Head).

- Engaging pupils by setting up and running out of school clubs

The Bulmershe School, Woodley, Berkshire, also used their grant to finance a Saturday school to focus on improving the pupils' performance in STEM. *"Teachers tell us that behaviour and attitude have both improved among children attending, and the fact that they do come every Saturday without having to, shows they enjoy it and find it helpful,"* (Jawwad Raja of Imaad group of mentors).

- Linking the STEM Access Grant with other schemes for example the BA CREST scheme

Mulberry School for Girls, Whitechapel, London, for example, used their STEM Access Grant to fund a series of master classes for its students at London Metropolitan University which used materials designed and developed with Bio-Rad a biosciences company. The projects carried out, which related to extraction of both plant and human DNA from cells and the production of biochemical precursors from fungi, gained accreditation via the bronze, silver and gold BA CREST awards scheme. *"The STEM funding has been incredibly beneficial to the girls who are taking part. We are seeing increased aspirations towards further education in general and science in particular, and those involved have increased in confidence and performance in science lessons"* (Penelope Nash, Gifted and Talented Co-ordinator, Science Teacher).

Section 4.1.5: Rolls-Royce Science Prize

The Rolls-Royce Science Prize is an annual, two stage competition open to teams of 2-6 teachers or related school staff, designed to promote teamwork within education institutions. The total prize fund is £120,000, the final winner receiving £15,000 for science education in their school or college (http://science.rolls-royce.com/).

The first stage of the competition is the submission of a science teaching project under one of three categories, 3-11 years, 11-16 years, and 16-19 years. Nine finalists are chosen to go on to stage two, and 50 schools and colleges of high standard are chosen to receive the Special Merit Award of £1,000. The nine finalists each receive an award of £5,000, a video camera and the help of a specially allocated mentor, to implement and complete their project. The finalists have 24 weeks to complete their program and submit a video diary of the progress, before the final judging. The data provided for 56 winners was analysed for the purpose of this Research Synthesis (see Annex 1, pp. 34-41). The results show that:

- The South East has the greatest number of winners (13) and the West Midlands has the least (1).
- Schools teaching 11-16 year olds have the highest number of finalists (44.5%), the majority (67%) of which are co-educated state schools.
- Eleven schools have been a finalist on more than one occasion, the most frequent of which are, St. Olave's Grammar School, Kent (4 winners), and Richard Huish College, Somerset (3 winners).
- It is interesting to note that a large number of successful applicants have also been awarded Royal Society Partnership Grants.
- An examination of the case studies has resulted in the identification of a number of good practices that may be used to encourage greater participation amongst other schools. Projects that are thought to increase pupils' interest in science are looked upon favourably. Good practice can be identified as:
- Projects that are hands on and can show pupils how STEM is applicable to everyday life

La Sagesse School, North Jesmond, Tyne and Wear, for example, built a Roman Apothecary Garden, Fairytale Willow village and a multi-sensory garden which the judges felt was *"real science learning in context".* St Stephen and All Martyrs' Primary School, Bolton, Lancashire, were awarded a prize for a scheme where pupils undertook an adventure of scientific discovery based on Darwin's expeditions. Judges said the project was funded because it was "*a real simulation with plenty of hands on activities".* Woodchurch High School, Woodchurch, Merseyside, carried out a robotics project to look at how adaptations in animals can be used to inform robotics design. The project aimed to teach pupils that the application of scientific knowledge can be used to solve real world design problems. The project was recommended due to its ambition in bringing together engineering and real world scientific observations.

- Links disciplines within the school

At Largs Academy, Largs, Ayrshire, Key Stage One pupils, for example, were given the opportunity to produce a creative instillation drawing on their scientific knowledge of "processes and living things". The project was praised for being cross-curricular using biology, chemistry, physics and art. Mulburry School for Girls, Whitechapel, London, for example, carried out a project to explore the life of the universe by bringing the science and art departments together. Science theory and religion were considered as pupils put together a time line of the history of the universe. The judges recommended the proposal for an award for its original and creative way of making the importance of science a central feature within the school.

- Furthers school development by linking the project with the national curriculum and benefits the wider community.

A project by Little Leigh Primary School, Little Leigh, Cheshire, was funded because the judges viewed it to be very beneficial to the wider community. The project was to set up a bank of resources, all about science, to be used in schools, as well as by local community groups.

Section 4.1.6: British Council Formula One

The F1 Team in Schools Challenge is a competition, open to all UK based secondary schools and colleges, to design and manufacture CO_2 powered model racing cars (dragsters). The project is designed to inspire a new generation of engineers, promoting science education. The challenge aims to help change perceptions of engineering, science and technology by creating a fun and exciting learning environment for young people to develop an informed view about careers in Engineering, Science and Technology.

F1 in Schools founding partners Denford, BAE SYSTEMS and Jaguar work together to produce an exciting educational experience for students and teachers alike, challenging negative stereotypes associated with engineering in a fun and positive way.

F1 in Schools is a not-for-profit company with the aim of raising the profile of engineering as a career through the CAD/CAM Design Challenge. The Challenge has a wide base of support and major UK sponsors include The IET, Denford, Jaguar Cars, The Learning Grid, City University London, Make your Mark, The Royal Academy of Engineering and the Year in Industry.

To enter the F1 in Schools project, each team must design a model CO_2 powered F1 Car of the future using a Computer Aided Design (CAD) package such as SolidWorks. Once the cars are designed, they are transferred into Computer Numerical Control (CNC) language using a Computer Aided Manufacture (CAM) package such as QuickCAM 3D. Cars are then manufactured on a CNC machine. For this reason the identification of good practice is not related to the way the teams wins but more towards the way the teams interact with each other and with external bodies. However, there are some schools who have had repeated success within the competition in the following years (see Annex 1, pp. 42-43), (http://www.f1inschools.co.uk).

At Sandhill View School, Thorney Close, Tyne and Wear, school teacher Gary Glover has been involved in the design challenge for the past two seasons. He realised that the challenge met many of the requirements for the GCSE specification and that it was a real project. The competition has been a massive success with pupils; *"What we wanted from this project was to raise achievement! The success the pupils have had have been highlighted in school, regionally (in local newspapers), nationally both via the F1 competition final and promotional work and through the DfES breakthrough project - Raising boys' achievement"*.

Avon Vale Training (http://www.avonvale.co.uk/index.php) became involved in the F1 in schools project 3 years ago because they realised it was good way to get young people into engineering and raise the profile of the apprenticeships they offer. They have the facilities to manufacture, test and race the cars and have assisted many schools in the competition. A similar centre in Birmingham, the Frankley City Learning Centre is one of a network of city learning centres providing technological support and training for schools in the area. It is a F1 in schools manufacturing, testing and race centre which runs F1 in schools training for teachers and students.

Woodlands Community School, Harefield, Southampton, forms part of a 10 school hub in Southampton which are part of a scheme to encourage CAD/CAM video conferencing. Kevin Baker set up an inter-schools competition as a practice run for the F1 in schools competition.

This Research Synthesis acknowledges that there are several other annual competition schemes awarded to school children that can also be classed as examples of good practice. These include, NESTA Future Innovator and Big Boost and Young British Engineering Awards and can be classed as examples of good practice. These schemes provide details about the projects, finalists and winners, together with the names of their schools.

Section 4.2: New Science Qualifications and Diplomas

Section 4.2.1: New Science Qualifications

The nature of school science curriculum and traditional methods of teaching have been identified as one of the key causes of lack of interest in science subjects amongst pupils. A survey commissioned by the Oxford, Cambridge and RSA Examinations (OCR) research team carried out in 2006 revealed that *'over half of 13–16 year-olds thought science lessons were boring, confusing or difficult'* (Noel, 2006: p.1).

In response to these concerns, the UK Government set out its vision and agenda, in 2003, for 14–19 year olds in education in the Green Paper *14–19, Opportunity and Excellence,* published in 2003. As a result, the then Department for Education and Skills (DfES), requested the Qualifications and Curriculum Authority (QCA) to revise its science curriculum at Key Stage 4 (14–16).

This exercise has resulted in the creation of two new dynamic and innovative GCSE science suites entitled, 'GCSE Twenty First Century Science Suite' and 'GCSE Gateway Science Suite'. They came into force in September 2006, complemented by other science qualifications. These new science qualifications are aimed at tackling the diminishing interest in science, inspiring students and sustaining their passion for science.

The 'GCSE Twenty First Century Science Suit

The 'GCSE Twenty First Century Science Suit' consists of six specifications which utilise common material, use a similar style of examination questions and have a common approach to coursework assessment. The content of this suite is based on a project devised by the University of York Science Education Group (UYSEG) as part of a QCA project on Science in the 21st Century. Centres piloting GCSE Science, GCSE Additional Science and GCSE Additional Applied Science have assisted in the development of these specifications. OCR is the only awarding body to have piloted any of the new GCSE Sciences. Candidates taking GCSE Science with GCSE Additional Science (or Additional Applied Science), or GCSE Biology, GCSE Chemistry and GCSE Physics, will have the experience necessary to progress to appropriate level 3 qualifications. This suite is supported by the Nuffield Curriculum Centre and the University of York Science Education Group. The new 21st Century science curriculum entails the inclusion of topical scientific issues that affect society as a whole such as GM foods or global warming, and mobile phone technology and it is more literary-based rather than focussing on theoretical aspects of science (source, www.ocr.org.uk).

The 'GCSE Twenty First Century Science Suite' was initially piloted by OCR, amongst seventy-six centres and the feedback from these centres was used to inform the development of the final specifications. Settle College and Horsforth School were amongst the first centres to pilot the qualifications. Settle College is a Technology College in rural North Yorkshire with around 580 students. The Head Science Teacher started all 172 of the centre's Year 10 students on the OCR Twenty First Century Science pilot. His views and comments published in the OCR report, in 2006, were generally positive. He, for example, commented that *"although the last 18 months or so have been scary and unpredictable, they have also been the most stimulating, exciting and rewarding times I have experienced in teaching. The courses really do address science issues of relevance and importance to citizens rather than simply being the first step in a scientific training that the vast majority wouldn't continue. It was rewarding but hard work", (Noel, 2006:p.2).*

GCSE Gateway Science Suite

This new suite of GCSE sciences comprises five specifications which utilise common material, use a similar style of examination questions and have a common approach to coursework assessment. The specifications in the Gateway suite emphasise explanations, theories and modelling in science along with the implications of science for society. Strong emphasis is placed on the active involvement of students in the learning process and the specification encourages a wide range of teaching and learning activities.

This is achieved by:

- Identifying activities and experiences which will excite students' interest, and linking these to scientific ideas and their implications for society.
- Providing opportunities to develop science explanations and theories.

In each specification there are three units of assessment, two externally set and marked unit examinations, each testing three teaching modules, and one internally assessed coursework unit. The reduced assessment burden allows for staged or terminal schemes of assessment. It has been claimed that pupils taking GCSE Science with GCSE Additional Science, or GCSE Biology, GCSE Chemistry and GCSE Physics, will have the experience needed to progress to appropriate level 3 qualifications (source, www.ocr.org.uk).

Section 4.2.2: New Diplomas in STEM

In 2004, the UK Government commissioned the 'Working Group' for 14-19 Reform, headed by Tomilson to produce a report to advise on reform of curriculum and assessment arrangements for 14 to 19 year olds. Building on the proposals and recommendation made already in a report produced by Professor Arian Smith in 2004, the Tomilson Report sets out a clear vision for a unified framework of 14-19 curriculum and qualifications (Smith, 2004; DES, 2004).

The report highlighted the importance of the scholarship in subjects to be given room to flourish, and high quality vocational provision to be made available from the age of 14. The report emphasised the importance of equipping young people with the knowledge, skills and attributes needed for HE, employment and adult life.

The report concluded that '14-19 learning were fragmented with a proliferation of qualifications of different types and sizes, few of which offer a balance between the knowledge and skills which everybody needs to play an active part in society and the specialised knowledge and skills for particular areas of learning and work' (p.4).

The report recommended that the 'existing system of qualifications taken by 14 -19 year olds should be replaced by a system of diplomas, available at entry, foundation, intermediate and advanced levels', and each diploma should be sub-divided into separately assessed components' (p.23).

Tomlison report's recommendations have resulted in the creation of a number of diplomas. On 23 October 2007, the Secretary of State announced plans to build on the success of the 14-19 Diploma programme by expanding the diploma offer to develop a new Science Diploma alongside of two other new diplomas, Humanities and Languages. These three new diplomas will be offered from 2011 onward.

The new diplomas will have the same structure as existing diplomas, with the same combination of principal learning related to, a particular subject area; generic learning delivering functional and personal learning and thinking skills; the extended project; and additional and specialist learning allowing learners to either deepen their subject knowledge in a particular field or broaden their studies by taking other subjects they are interested in.

The new diplomas will be available across all three diploma levels, i.e., Foundation, Higher and Advanced. They will be built upon the best of existing GCSE and A Level qualifications with specially-designed content, developed by a group of leading academics and employers.

All of the diplomas will have the same rigour as GCSEs and A-Levels. But they will also offer students more coherent learning programmes, combining breadth with opportunities to develop greater depth in particular subject areas. It is intended that a student studying a Level 3 Science Diploma would have all the necessary science knowledge for studying research intensive degree courses in science. The new diplomas will also enable students to develop the same personal, learning and thinking skills necessary for progression into FE, HE and work, as those choosing the first 14 diplomas.

The diploma in Manufacturing and Product Design, for example, is a work relevant qualification that covers the whole process of manufacturing, from the purchasing of raw materials through to the sale of the finished product. This process encompasses design, procurement, human resources management, finance, marketing and other relevant issues such as sustainability and globalisation. It has a strong business focus and aims to give young people essential lifelong knowledge and skills such as, creativity and innovation, the ability to work on their own initiative or as part of a team, and communicating effectively with others (www.manufacturingdiploma.co.uk).

There are views both for and against the diplomas. The Government believes that diplomas are exciting and innovative new qualifications for 14-19 year olds. They have been created to provide a real alternative to more traditional education and qualifications and are the most important changes to the country's education system since the introduction of GCSEs. It has been claimed that the diplomas will give young people a fully rounded qualification, which combines theoretical and practical learning, including functional English, Maths and ICT, to equip them with the skills, knowledge and understanding they need for further or higher education and long-term employability (BBC, 2008a).

However, there are concerns about the impact of the functional skills requirement on the uptake of the diploma. The QCA qualifications watchdog believes that the required "functional" skills in literacy, numeracy and computing may put children off taking the new courses, and as such will have a significant negative impact on pass rates.

There are also concerns that diplomas may be regarded as ‘second-class’ courses by universities and employers. The Department for Children, Schools and Families (DCSF) has the responsibility to ensure that diplomas would not be seen as "second-class courses". It has been suggested that functional skills in English, maths and ICT will, in the future, become mandatory requirements for all students whether they study science or not, (ACME, 2008).

Section 5: Government Policy and Targets for Stem Education at Primary and Secondary Levels

As mentioned in Section 4, the UK Government strives to preserve interest in STEM subjects at secondary and tertiary level education. The Science and Innovation Investment Framework 2004-2014, next steps, published in 2006 set new ambitions, including to:

- ‘achieve year on year increases in the number of young people taking A levels in physics, chemistry and mathematics so that by 2014 entries to A level physics are 35,000 (currently 24,200); chemistry A level entries are 37,000 (currently 33,300); and mathematics A level entries are 56,000 (currently 46,168);

- continually improve the number of pupils getting at least level 6 at the end of Key Stage 3 (11-14 year olds);

- continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs; and

- step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers so that by 2014 25 per cent of science teachers have a physics specialism; 31 per cent of science teachers have a chemistry specialism; and the increase in the number of mathematics teachers enables 95 per cent of mathematics lessons in schools to be delivered by a mathematics specialist (compared with 88 per cent currently)’ (p.15).

To meet these ambitions, the Government has announced a package of measures to improve the skills of science teachers, the quality of science lessons and increase progression to A level sciences, including new commitments to:

- ‘make science a priority in schools by including science in the School Accountability Framework;

- an entitlement from 2008 for all pupils achieving at least level 6 at Key Stage 3 to study three separate science GCSEs, to increase progression to, and attainment at, A level science;

- continue the drive to recruit science graduates into teaching via Employment Based Routes with new incentives to providers of £1,000 per recruit to attract more physics and chemistry teachers; and

- develop and pilot a Continuing Professional Development (CPD) programme leading to an accredited diploma to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively’ (p.7) .

The Science and Innovation Investment Framework 2004-2014 set out the Government’s approach towards achieving a step change in the level of science skills in the UK economy. It has outlined the Government’s ambition to create an education and training environment that delivers the best in science teaching and learning at every stage, and is responsive to the needs of learners, employees, employers and the wider economy. More specifically, the Government's ambitions are to achieve a step change in:

- 'the quality of science teachers and lecturers in every school, college and university;
- the results for students studying science at GCSE level;
- the numbers choosing science, engineering and technology subjects in post- 16 education and in higher education; and
- the proportion of better qualified students pursuing R&D careers', (p. 44).

There are some indications that some progress has been made in implementing the measures outlined in the S*cience and Innovation Investment Framework 2004-2014*. Key achievements between 2004 and 2005 include:

- 'implementation of training bursaries and Golden Hellos to attract more science teachers into the profession;
- support for the Continuing Professional Development (CPD) of science teachers, for example through the establishment of Science Learning Centres in each region;
- the launch of a cross-cutting programme to rationalise and increase the effectiveness of the range of initiatives supported by Government and its partner organisations to promote interest in STEM subjects at all levels; and
- the creation of a Women's Resource Centre to work in partnership with businesses to increase the opportunities for professional women in science, technology and engineering' (p.45).

However, the Government remains concerned that progress towards meeting its ambitious targets is relatively slow in some areas and despite the progress in taking forward the measures contained in the *Science and Innovation Investment Framework 2004-2014,* the significant challenges remain to reverse the current trends.

On 24 January 2008, Schools Minister Jim Knight outlined a £140 million strategy to educate the next generation of scientists and mathematicians and help recruit and train more science and maths teachers.

The £140m package for Science Technology Engineering and Mathematics includes:

- ‘£31 million for recruitment and retention including £11.4 million so that teachers can retrain to become maths, physics and chemistry specialists - every teacher who retrains will receive a financial incentive of £5,000;
- £50 million for continuing professional development including:
- £18 million to fund the regional science learning centres plus continued funding for the National Centre for Excellence in the Teaching of Mathematics;
- £4.5 million for schools to encourage them to release teachers for professional development at our science learning centres;
- £34 million to help boost the number of young people studying science STEM subjects post-16 including up to £9 million so that more pupils can take the three GCSEs in physics, chemistry and biology; and
- £9 million to improve pupils' learning experience through enhancement and enrichment’

Section 6: Summary, Key Findings, Gaps in Knowledge, Good Practice, Concluding Remarks and Recommendations

Section 6.1: Summary

- This Research Synthesis was commissioned by the Economic and Social Research Council (ESRC), as part of its Science in Society Strategy, jointly with the Department for Children, Schools and Families (DCSF). The prime purpose of the Synthesis was to gain a better understanding of successful interventions and practices used by schools and colleges to reduce drop-out rates in science, technology and mathematics subjects.
- The Research Synthesis has attempted to explore, through an examination of existing research, reports, policy and publicly available information, what has been learned from secondary and college level institutes which have instigated different practices to retain students in science and technology subjects and identify any trends in this area, where possible.

* The Synthesis has provided a review of research relating to uptake, as well as a resource for policy and decision makers in science, government, industry and the education field.

* The methodology incorporated a combination of in-depth literature review, desk research, web searches, qualitative and quantitative data collection and analysis of publicly available data, where applicable. The methodology has acknowledged the literature, governmental and non-governmental reports, bodies, organisations, policies, initiatives, schemes, and programmes relating to STEM activity at primary and secondary education levels in the UK and where possible in the USA.

* Science and mathematics subjects are identified as being 'critical' to the future supply of qualified scientific workforce and are of strategic importance to the nation because of the increased competition from rapidly advancing economies around the world (HMSO, 2004).

* Over the last decade, the UK has experienced a marked decrease in the number of A-Level students taking mathematics, chemistry and, in particular, physics. In fact, it has been suggested that physics is in danger of disappearing as a subject in its own right from the state education system due to redefinition to general science and shortage of qualified science and mathematics teachers (Smithers and Robinson, 2005). It has been suggested that this may also apply to chemistry but to a lesser degree (Moor et al, 2006).

* In general, there is a particular concern as why more pupils, particularly girls, who do the core science and mathematics A-Levels opt out of studying these subjects for their degrees and why a significant proportion of science and mathematics graduates choose not to pursue related occupations (Wynarczyk, 2008).

* Girls outperform boys in science, technology and mathematics subjects at GCSE. However, there is a downward trend, in real terms, in the total number of girls studying mathematics, engineering and the physical sciences, indicating a future shortage of people in the SET labour force if the number of boys and men studying these subjects falls or remains the same (Roberts, 2002; DCSF, 2007). The gender imbalances in STEM subjects become even more pronounced post-secondary education where young girls and women progressively depart from what has become known as the 'STEM leaky pipeline' (Wynarczyk, 2007a).

- Participations in STEM vary among different ethnic minority groups. In terms of their percentage of the general UK population, Chinese, and Indian people are over-represented in STEM compared to their White UK counterparts. In contrast, some ethnic minority groups attain significantly below the national average and their under-achievement is much greater than the gap between boys and girls. African-Caribbean people are most severely under-represented in STEM education in the UK, due to the inequalities of their educational outcomes in mainstream education, and unequal access to role models and promotional activities in STEM. Bangladeshi people are also under-represented in STEM both in terms of occupations and educational attainment, with the problem of under-representation being more prominent among Bangladeshi girls and women (Jones and Elias, 2005; Gago, 2004; EMSET, 2004; DfES, 2007a).

- There also regional disparities in terms of participation in STEM subjects across the UK. A recent mapping exercise carried out on behalf of the UK Resource Centre (UKRC) for Women in SET revealed that in 2005/06 the achievements in core STEM subjects primary and secondary levels varied across the English regions, Scotland and Wales, the lowest performing region was Yorkshire and Humber particularly for Physics, Double Award Science and Mathematics. In the same year, the achievements of pupils' in Scotland and Wales were below UK national average in STEM subjects (Wynarczyk, 2008).

- The pupil's engagement (or lack of it) in STEM subjects has been the subject of numerous studies for over several decades (Osborne, 2007), particularly since 1950s when science in primary school did not develop significantly due to lack of teacher expertise, lack of resources, large classes and the eleven plus examination (Murphy and Beggs, 2006).

- It has been suggested that the changes in the UK science curriculum since the 1960s, a crucial decade, when science became compulsory at primary level have largely reflected a growing acceptance that 'science is a subject for all students up to age 16 rather than one chosen by a minority as a preparation for more advanced study' (ASE, 2006, p.9). This is believed to have infused significant interests amongst the research community to identify and examine those factors that, positively or negatively, influence the attitude and take up amongst pupils, particularly at post primary education.

- Numerous academic studies and government reports have attempted to identify those factors which may have positive or negative impact on take up of science subjects, achievements and subsequent choice of remaining in the science pipeline, i.e., pursuing further education and eventual careers in science (see for example, Osborne et al, 2003, Osborne, 2007; Murphy and Beggs, 2006; Haste, 2004; ETB, 2005, 2007; Roberts, 2002, to name but a few).

- Current research suggests that the diminishing interest in school science subjects may be, amongst several other factors, attributed to the lack of knowledge and understanding of the real importance; values and contribution of science to everyday life; the traditional methods of teaching; the availability of sufficient qualified and enthusiastic teachers with scientific and mathematics background; mismatch between the values communicated by science and the manner in which it is taught; the aspirations, ideals and developing identity of young adolescents; the negative attitudes of young people towards science in general; gender; ethnicity; lack of role models; and out of date scientific laboratories and equipments.

- The UK Government strives to preserve interest in STEM subjects at secondary and tertiary level education. It has shown a firm commitment and is determined to identify new ways and inject more money to motivate and inspire many more young people to take up STEM subjects and achieve good results, following their journeys into the STEM pipeline, i.e., taking up science subjects post-16 study and university or vocational education, and on into rewarding and progressive careers (DCSF, 2008).

- The UK Government is actively encouraging greater participation of pupils in STEM subjects and allied fields through an extensive and overwhelming array of national and regional bodies, initiatives, programmes, schemes, academics, new qualifications and diplomas. It has recently increased, substantially, its STEM education budget to £140m, for the period 2008 to 2011, yet as another serious attempt to reverse the current downward STEM trends.

- There are a number of major government, nongovernmental and charitable organisations, bodies, institutes and foundations that either solely as part of their responsibilities, or voluntarily strive to promote science and innovation amongst young people at schools, through the development of numerous initiatives, measures, web-based resources, and schemes. These include, DCSF, SETPOINTS, British Council Science, Royal Society, Science Institutes (e.g., Chemistry, Physics, Engineering), National Endowment for Science, Technology and Art (NESTA), Engineering and Technology Board (ETB), Wellcome Trust, Gatsby Foundation, Science and Discovery Centres, Science and Learning Centres, and Science City Initiatives, to name but a few.

- In 2004, a STEM Mapping Review was initiated which revealed over 470 STEM initiatives run by the then DfES, DTI and external agencies with the vast majority found to be targeted at primary and secondary sector, mainly, focused on science and mathematics as two priority areas. The Review highlighted the lack of coherence of the 'plethora' of existing initiatives and revealed the lack of readily available evaluation (DfES, 2004).

- The Review also identified a number of policy gaps such as the lack of specific initiatives targeted at encouraging women, girls and ethnic minorities into STEM and highlighted the need for better links across schools/FE/HE/employers in order to ensure that a transition is made across the education stages of STEM pipeline (key stage education to degree level, followed into career).

- Subsequently, in 2006, the STEM Cross Cutting Programme was initiated by the Government and was given the task of examining around 200 initiatives identified through the original STEM Mapping Review 2004 and analysing over 70 of them in details. This Mapping Review concluded that there are far too many schemes and initiatives supporting STEM, mainly directed at school-age students, each of which with its own overheads. While many of them are of high quality, despite recommendations made by the Mapping Review 2004, they continue to remain mostly uncoordinated and largely unevaluated (HSMO, 2006).

- However, despite the recommendations made by both Reviews, new STEM bodies, web-based resources, initiatives and schemes are emerging continuously at national, regional and local levels.

Section 6.2: Key Findings and Gap in Knowledge

The results of the literature review, carried out for this Research Synthesis, reveal that whist there is an huge body of academic research and commissioned studies on the topic of the views and attitudes of young people towards STEM (see for example, Brown, 1975; Doherty and Dawe, 1988; Bennett, 2001; Osborne and Collins 2001; and Osborne et al, 2003), there are several key areas that remain under-researched or neglected. Furthermore as mentioned above, existing academic research and government reports focus, principally, on the identification of factors that (positively or negatively) influence the take up of science subject at schools and beyond. However, there is, relatively, less research on the identified factors. As Sir Roberts Review has highlighted, quantitative and empirical evidence on relative importance, cumulative effects of, and interrelationships between separate but equally important factors that influence the take of SYTEM subjects are scarce. Sir Roberts Review stated in 2002 that 'tackling any one aspect whilst neglecting others is unlikely to deliver a strong overall improvement' (p.18). The following section provides an overview of some key findings and gaps in the knowledge, highlighted by this Research Synthesis.

- Although Osborne et al, (2003, p.18) notes several studies that have identified the 'influence of classroom environment' as a significant determinant of attitude' (e.g., Haladyna *et al.* 1982; Myers and Fouts 1992;Talton and Simpson 1987), there does not appear to be any known studies which conclusively or strongly has determined whether teachers with backgrounds in science and mathematics have a direct or indirect influence on pupils pursue of STEM subjects at school and beyond.

- A new report produced for the Royal Society in 2008, entitled, 'A Higher Degree of Concern', highlights a fundamental issue, i.e., the lack of an up-to-date detailed knowledge of the number of UK primary teachers with a maths or science background. Furthermore, it states that the two main sources of data on secondary school science and maths teachers are not reliable enough to represent the national picture (Royal Society, 2008).

- The Royal Society report (2008) shows that the shortage of science and maths teachers is worsened by lack of reliable data and statistics. The report suggests that targets set by the Government are themselves based on unreliable information, with the teacher shortage likely to be much higher. The report reveals that in the UK there is no accurate estimate of the population of science and mathematics teachers (Royal Society, 2007a). This has been attributed, partly, to the fact that there is no consensus about how a "specialist" science or maths teacher should be defined (Royal Society, 2007; BBC, 2008a). This is an area of urgent attention.

- Current research, policy and government reports on SET trends focus, mainly, on the participation of boys and girls and, in more recent years, the ethnic minorities, mainly, as a response to Sir Roberts Review (2000). In comparison very little attention is paid to demographic issues. Sir Gareth Roberts Review (2002), using STEM data in 1999, considered regional differences and concluded that pupil choices of A-Levels between regions did not vary greatly although a greater proportion of students in the London region seemed to choose mathematics and chemistry than in other regions. It is disappointing that the Roberts Review did not fully investigate regional differences in terms of the level of take up and performance in STEM subjects in the light of causes of disparities (e.g., socio economic factors). As a result, demographic issues remain a neglected area of research and policy.

- STEM subjects, in terms of level of participation, attainment and achievement amongst pupils at primary and secondary education located in different regions of England, Scotland and Wales have not been the subject of a comprehensive investigation in 'its own right'.

- There is only limited academic research that has identified environment, culture and social class amongst factors influencing the take up of STEM subject at school (see for example, Osborne, 2004; DfES, 2007a). The representations of men and women as science and technology professionals vary across the regions of the UK and to the disadvantage of less favoured regions such as the North East of England. A recent empirical survey of scientific-based SMEs carried out by Wynarczyk in 2006, as part of the ESRC Science in Society programme, demonstrates that women, compared with their male counterparts, are seriously under-represented in the scientific labour market, particularly in R&D and more so in the North East of England, a region with low innovation and R&D intensity. There is no evidence of how STEM trends, activities and policies are aligned to such important and underlying factors (Wynarczyk, 2007a).

- The Sir Roberts Review has identified 'out-of-date' scientific laboratories and equipment as one of the deep seated issues, alongside the shortage of well-qualified teachers, which also needs to be addressed in order to improve the UK's future supply of high science and engineering skills. A study carried out in the USA shows that laboratory experiences, as a part of most USA high school science curricula, have been taken for granted for decades, and they have rarely been carefully examined (Singer, *et al,* 2005). In the UK the impact of the nature and use of laboratories on take up of science subjects also remains a neglected area of research.

- A full assessment of the state of school laboratories in England is not available as data is not collected centrally and there remains a huge gap in the data. Limited data shows that out of date laboratories and equipment are still found in many schools, preventing practical science work being undertaken and damaging the perception of science in the minds of young people. Research commissioned by the Royal Society of Chemistry in 2004, for example, showed that only 35 per cent of the 26,340 secondary school science laboratories in England were graded good or excellent. Of the remainder, 25 per cent were considered either unsafe or unsatisfactory for the teaching of science.

- Numerous STEM bodies, initiatives, measures and schemes that currently exist, in aggregate, form the major components of STEM education activity at primary and secondary levels and Government expenditure. They share a common mission, to inspire children and young people to become the scientists of tomorrow. However, there is very little known about these organisations and their remits. These organisations have their own website and although some tend to commission research, there is no published report about their own activities. Consequently, we know very little about their contrition and real impact on increasing the take up of science subjects

- There remains a lack of overall co-ordinations of these bodies with regards to their STEM education activities. It is not apparent how they relate to each other, let alone link to initiatives covering other parts of the STEM pipeline. As such, it is not possible to assess whether or not their activities are complementary or overlap. It is difficult to determine how they approach schools, teachers and pupils to raise awareness and encourage take up, or whether they rely solely on potential participants to visit their website and find out for themselves.

- It is not clear how STEM initiatives are linked to the widening participation agenda, and the integral part of the remit of RDAs to address issues of social inclusion in economic regeneration for their respective regions. It is not clear whether these initiatives have any provisions to engage the socially disadvantaged, particularly groups of individuals lacking skill-sets that are not aligned to the demands of the region, to become inclusive contributors to STEM and allied education and occupations. These issues are worthy of further policy and research attention and need to be explored further.

- The STEM Mapping Review, conducted in 2004, highlighted the lack of coherence in the 'plethora' of existing initiatives and revealed the lack of readily available evaluation. The result of the overall mapping exercise showed that less than 50 per cent of initiatives had some methods of evaluation in place. It was revealed that when the evaluation was carried out, it generally did not incorporate elements of supply and demand and as such makes it difficult to assess and measure the real impact on improving the take up of STEM subjects and whether the supply of STEM graduates is being addressed, these issues still need to be tackled.

- In addition, the Mapping Review highlighted the existence of numerous local initiatives with small scale funding which may have a localised impact on raising attainment and improving the quality of teaching. These are demonstrated in the Excellence in Cities (EiCs) and Education Action Zone (EAZs) programmes. The Review concluded that these programmes link and mesh together well with regard to delivery and support of the national strategies. The review commented that these initiatives may make an impact locally, but questioned whether they have any major impacts in achieving DfES/Government objectives. The Review emphasised the importance of measuring the real impact and added value of STEM initiatives. These issues remain to be assessed.

- Whilst STEM's education budget, initiatives and schemes continue to increase in terms of numbers and activities, despite the recommendations made by the Review, their real impact on improving the take up, performance and achievement in STEM subjects has not been investigated and, as such, their real contribution to STEM education may be undermined. This is a highly neglected area of research and policy. It may be the case that the initiatives generally manage to reach their annual targets, in terms of number of participants (schools, teachers and pupils) and spend the allocated funding. This may be sufficient to qualify them for subsequent funding.

- As the Mapping Review 2004 has stated, access to, and information about, initiatives are key factors in their take-up by learning providers and learners. Evidence provided in the review also highlighted that there is paucity in the knowledge about their nature and level of activities, take up, added value and impact due to lack of evaluation and a focal point of co-ordination. The results of this Research Synthesis reveal that this has continued to be the case.

- The connectivity technologies have provided a significant opportunity for these initiatives to set up their own dedicated websites which are used as the main engine for disseminating information. Due to the vast numbers of initiatives it is not easy to access and source information about appropriate initiatives which may affect the both demand and supply side factors. This is a criticism that is often made against government-sponsored initiatives in any area of the economy and it is clearly something that needs to be addressed.

- There is a lack of a comprehensive web-based directory or user guide that brought together information about these organisations under one single source that could promote their initiatives and schemes more widely and directly to the right user groups. However, this Research Synthesis acknowledges that SETPOINTs have responsibility for identifying and publicising STEM schemes and initiatives in an assigned area, which controls the number of schools and colleges they work with, ensuring the highest quality of service and a more personal and efficient channel of communication. This also enables them to respond to specific local and regional needs, whilst maintaining focus and ensuring alignment with national curriculum changes and requirements. Furthermore,

- Limited studies, evidence and evaluation of STEM initiatives, grants and schemes that currently exist are, mainly, based on views expressed and comments made by teachers and pupils who have participated in their initiatives and schemes as opposed to any serious attempts to measure and demonstrate the real impact on take up and achievements.

- Only a small proportion of STEM initiatives and schemes provide contact details of participating schools, teachers and pupils. Few initiatives and schemes provide selected case studies or success stories of participating schools e.g., Royal Society partnership Grants, Chemistry at Work, STEM Access Grant, British council F1), the only available source of information which provides details of specific innovative projects, measure and activities developed by participating schools. They also echo the participants' positive views and comments, publicised via their websites, newsletters, participating schools websites and newsletters, and in some cases in the education journals, conferences, LEAs' Bulletins national and local press.

Section 6.3: Identification of Good practice in the UK

This Research Synthesis has resulted in the identification of several schemes and initiatives that may be recognised as examples of 'good practice', amongst which are the Royal Society Partnership Grants, Chemistry at Work, STEMNET Scheme, Rolls Royce Science Prize and British Council Formula One. These initiatives and schemes have been identified as examples of good practice based on several interrelated key criterion as follows:

- Providing contact details of participating schools, teachers and pupils.
- Providing detailed case studies or success stories of participating schools and projects which tend to echo the participants' positive views and comments, publicised via their websites and newsletters.
- Case studies that provide information about the nature of the projects and activities supported and, as such, provide an invaluable source for the identification of good practice and innovative practices that can be replicated elsewhere in other schools and which may become permanent features of the science subjects, qualifications and diplomas.
- Recommending new applicants to consult successful projects and case studies which are on their websites to generate ideas for their projects and increase the chances of making a successful application.
- Publicising and encouraging participating schools to enter other competitions and making use of role models, mentors and ambassadors, offered by other initiatives and schemes.
- Providing links and partnership with HEIs, employers and scientists, as well as providing links and partnership amongst schools and colleges to share good practice.

The analysis of these initiatives and examination of their case studies have resulted in the identifications of schools and colleges that have participated in above initiatives and have developed and implemented innovative projects and practices that can be identified as examples of good practice. Over 600 schools and colleges have been identified. Some additional information have been obtained, including location (city and region), and type (e.g., mixed, single sex and special schools), as well as the contact details of teachers, pupils and project partners who have taken the leading roles in the development of projects and applications. This exercise has resulted in the creation of a unique database. This exercise has also resulted in the identification of a sample of schools that have been successful in obtaining multiple grants from one scheme, as well as participating in other schemes.

In the UK, there are several networks and organisations which aim to foster the interest and participation of young people in science by providing an avenue to role models, mentors, ambassadors, and networking opportunities. They include, The Royal Society Role Model Study, the Science and Engineering Ambassadors (SEAs) Programme, Computer Clubs for Girls (CC4G), The Vega Science Trust, The British Society of Science, SEMTA, SETNET, SETPOINTS, RCUK's Research in Residence Programme.

This Research Synthesis has also examined the importance of role models and ambassadors, as well the examination of several role mole schemes. Some areas of good practice have been identified:

- The role model schemes and initiatives, in general, aim to expose young people to accessible role models, i.e., people from a broad range of STEM disciplines and careers at all levels and ages. They include enthusiastic and inspiring people who have achieved, or are pursuing, successful scientific careers and education and have passion for science, the role models volunteer to inspire others. The Royal Society's Role Model Schemes, for example, has produced several 'Good Practice Guidance' for schools, teachers and practitioners and one on how to become a role model and what it entails (Royal Society, 2007).

- The Royal Society also actively encourages its Fellows to become role models and participate in extra curriculum activities at schools. The Royal Society's website provides a list of the Fellows, together with contact details, and encourages schools to invite Fellows to their Schools. However, the extent to which Schools are aware and engage these Fellows is largely unknown, let alone the real impact of the greater take up of STEM science subjects and beyond.

- Ambassadors who are involved in the Science and Engineering Ambassadors (SEAs) Programme are individuals from a wide variety of STEM backgrounds, from all across the UK, who offer their time, enthusiasm and expertise to help schools to inspire young people in STEM. As can be seen from information provided in Annex 1, p. 9., the programme has over 17,500 Ambassadors, with plans to expand this to 18,000 by the end of March 2008. The information about the programme is available from the SEA's website. SEA has also produced a document based on several case studies of its inspiring Ambassadors.

- There are also a limited specific role model programmes relating to ethnic minority groups. For example, The African-Caribbean Network for Science and Technology, for example, runs role model programmes for young Muslims. Within the scheme, parents are always consulted, especially if activities are taking place outside school. In some cases, in response to parents concerns, single sex group activities have been carried out and female students only interact with female role models. The support of parents is regarded as crucial (http://www.royalsoc.ac.uk).

Section 6.4: Some examples of Good practice from the USA

This Research Synthesis has, to a limited extent, examined some literature and specific schemes and initiatives, particularly with regards to gender imbalance in STEM. The results clearly demonstrates that any future or follow up studies should incorporate a more comprehensive literature review and examination of schemes in the USA in order to identify areas of good practice that may be replicated in the UK. Some examples of good practice identified by this Research Synthesis is summarised as follows:

- Kahle and Meece's paper on gender issues in the classroom in the USA published in 1994 cited two studies that showed that teachers who had a high proportion of girls continuing to enrol in high school chemistry and physics used specific teaching practices, which included, laboratory work, discussion groups, quizzed students weekly, stressed creativity and basic skills. They also used numerous printed resources rather than relying solely on one textbook. They had attractive classrooms, decorated with posters and projects, and kept live plants and animals in their laboratories (Kahle and Meece, 1994).

- Another USA study carried out by Freedman 2002 investigated the effect of laboratory work on achievement and attitude to physics of grade 9 students using an intervention and control group. They found that those girls who had taken part in laboratory work intervention improved their science achievement compared with girls who had received traditional teaching with no laboratory component. There was no difference between the achievement of boys and girls in the laboratory group, whereas the achievement of girls in the group that had not undertaken any laboratory work was less than that of boys in that group. The study concluded that laboratory participation was the reason for the higher achievement of the girls.

- In the USA, a great deal of attention is focused on the development of specific initiatives to encourage greater retention of young girls in STEM education. Specific examples are given below:

- In the USA, the Association for Women in Mathematics is a non-profit organisation dedicated to encouraging women and girls to study and have active careers in the mathematical sciences. The association offers educational resources for teachers and students including, biographies, careers forums, awards and scholarships. The Association for Women in Science is similarly themed and is dedicated to achieving equity and full participation for women and young girls in science, mathematics, engineering and technology. Particularly relevant programs undertaken are "take our daughter to work day" and "women in science day" both carried out at universities, where established female scientists share their experiences and expertise with younger students. (http://www.awm-math.org)

- The Young Women in Science Program which began in 1999 operates at the University of Kentucky Chandler Medical Centre. It encourages young women from rural Appalachia to pursue careers in drug abuse research or related scientific fields. Participants receive training, education and mentoring over a three year period and take part in intensive three week sessions each summer and five weekend sessions during the school year. The girls also receive mentoring from female research and community leaders and at the end of the program they receive a stipend and college scholarship. The progress of all girls who complete the program are monitored and evaluated for at least 5 years to assess the impact of programme on subsequent STEM education and career. (http://www.uky.edu/PR/News).

- Evidence presented by the Association for Women in Science also indicates that schemes such as those above are resulting in an increase in the take up of STEM subjects. Women as a percentage of all bachelor's recipients for physical science between 2000 – 2004 has increase from 41.7 – 42.1 percent, for engineering it is 20.1 – 20.5 percent and for biological and agricultural sciences a rise from 57.3 – 60.1 percent is seen (Data source: tabulated by National Science Foundation/Division of Science Resources Statistics; data from the Department of Education/National Centre for Education Statistics: Integrated Postsecondary Education Data System Completions Survey).

Section 6.5: Recommendations and Concluding Remarks

1. There is a huge amount of activities is going on across the whole disjointed components of STEM research and education spectrum. This Research Synthesis has brought together information and data about different components of the STEM activities. This Research Synthesis has resulted in the assembly of data and information on numerous STEM bodies. This has led to the development of a pilot directory of some major initiatives, distributed in an event organised in March 2008, as part of the 'ESRC Festival of Social Science 2008'. Following the

event, Dr Andy Pulham, Head of Science, Royal Grammar School, Newcastle upon Tyne, who participated in the Q&A Panel of Experts, commented '*I applaud your initiative to highlight opportunities for STEM projects - the directory is a massive step forward. When will it be published?'* This comment demonstrates the need for a major directory of STEM initiatives and schemes. The format of this pilot directory may be used as the basis for the creation of an easily accessible and informative web-based directory of the relevant bodies and initiative, classified according to the intended user groups, a 'focal point' or a 'platform' to be widely publicised amongst all schools and colleges, through, DCSF and Royal Society, in order to raise awareness and improve the take up and impact throughout the UK.

2. It is important to build upon this Research Synthesis and the resources it has assembled to undertake a major review and evaluation of STEM bodies and their initiatives with regards to their STEM education activity at primary and secondary education. It is also important to investigate how these initiatives are strategically aligned to regional issues raised in this Research Synthesis, as well as link amongst themselves and with strategies and initiatives that cover other parts of the STEM pipeline (i.e., further and higher education and career).

3. Research has demonstrated that extra curricula activities outside the class rooms can add value and spark interests in science amongst children and young people in several ways. However, there has been no survey of schools to assess the real impact and contribution of extra curriculum activities on greater participation and better performance and achievements. It has been possible, for the purpose of this Research Synthesis, to identify some 600 schools and colleges that have instigated different practices to retain students in science and technology subjects through participation in a number of initiatives and schemes. It has only been possible to analyse the nature of their projects and activities through the examination of a limited number of case studies. Given that little is known about the value-add of post-participation in STEM initiatives, more time and resources should be devoted to collect and analyse contextual quantitative and qualitative information from beneficiaries (schools, and their teachers and pupils, as well as partner organisations) to explore the outcomes of participation in STEM initiatives.

4. Presently, there is no concrete evidence to show whether or not there is a positive link between the improvement in the take up of and higher achievement in STEM subjects and participation in extra curricula activities. Assessing the real

impact requires some rigorous statistical tests linked to annual GCSE and AS/A Level results which are available via LEAs. It is important to build upon the list of schools and case studies assembled as part of this Research Synthesis to embark on a major empirical survey of schools, through a dedicated questionnaire. There is a need for an in-depth investigation and obtain information needed to assess the performance 'before and after' the introduction and implementation of innovative practices. It is also imperative to obtain such information to assess the performance of such schools and colleges against other schools and national, regional and local trends (analysing publicly available statistics and data). It is also important to examine the characteristics of high performing schools and assess the extent to which they participate in STEM initiatives and extra curriculum activities. It is anticipated that such a study will assist in the identification of good practice that can be replicated elsewhere, identification of barriers and obstacles to participation, level (lack) of awareness of initiatives, and incentive and rewards offered to teachers and impact on their career progression.

5. The STEM Review 2006 suggests that the Science and Discovery Centres are viewed by the formal sector, to be on the 'periphery of science education'. The report highlights the need to improve the integration of formal and informal learning, and to support links between the Science and Discovery Centres and formal education programmes. The results of this Research Synthesis reveal this could also be the feature of the most STEM initiatives and schemes. STEM initiatives and schemes, in general, provide a one off opportunity for participation, their take up is not compulsory and not linked to formal education.

6. Becky Parker, Head of Physics at Simon Langton Grammar School for Boys, Canterbury has recently commented '*there is concern that many of the new initiatives get taken up by enthusiasts while there remain schools that do not even accept offers of free educational resources from organisations such as Planet Science'* She further comments that, *competitions, clubs, trips and other extracurricular activities all boost morale and stimulate enthusiasm for science. Yet again, however, in addition to the obvious time pressures of the curriculum, health and safety worries mean that many schools limit how much teachers can take students out of the classroom'* (www.newtonapples.org.uk). It is important that existing and new initiatives take such important comments more seriously and attempt to find solution to remove barriers and obstacles to encourage greater take up by schools and colleges.

7. It is important to ensure that STEM support is accessible and delivered in the most effective way to every school, every college, learning provider and learner as recommended by the Mapping Review, 2006. It is also equally important to investigate ways of ensuring that innovative measures and initiatives will become part the formal education and culture of schools. There is a need to investigate and identify ways that help to remove barriers to participation in extra curriculum activities. Greater incentives and rewards should be given to teachers as they have pivotal role in the generation of ideas and development of STEM applications and projects.

8. It is highly imperative to build upon the case studies collated as part of this Research Synthesis and as part of the recommendation made above, to further investigate the nature of innovative projects, experiments and events pioneered and developed by schools, teachers, pupils and partners for which they have received grants and sponsorship from the STEM initiatives and schemes in order to assess whether there are areas that could be replicated elsewhere or become part of the formal education.

9. It is also important to identify children and young people who have participated in award schemes such as NESTA' Future Innovator and Young British Engineering awards to investigate the impact of participation on their decision to pursue science further. It is also important to engage such inspiring young people, through initiatives such as AES Ambassador's Programme to act as role models to encourage and inspire other young people to participate.

10. Over the past few years, there has been a continuous growth in the number of qualifications and diplomas in other areas such as fashion and 'film and media studies' which may be more popular, particularly, amongst girls. The latest development include, a new diploma in event management introduced by McDonald's which has achieved the standards for awarding accredited qualifications at Level 3 by QCA (BBC NEWS, 28 January, 2008). These new diplomas and qualifications could indeed add to the diminishing interest in the take up of science subjects that already exist. There a need to investigate the level and take up of these new qualifications and to assess whether they have any negative impact on the take of STEM subjects.

11. Despite numerous initiatives and schemes that exist there remains the absent of a highly import initiative alongside the existing initiative, a 'STEM Chrysalis' initiative that could inspire pupils from early age to become the science teachers

of tomorrows, This can be developed and inspire children around an important natural metamorphosis, as a caterpillar grows and develop inside the pupa to become a butterfly. One of the factors influencing the lack of take up could be attributed to the general lack of understanding and appreciation amongst young people of their potential future role, responsibility and contribution to education, as well as industry, scientific and technological advancement once they turn into adults.

12. As mentioned above STEM initiatives generally share a common mission, 'to inspire children and young people to become the scientists of tomorrow'. Teachers who teach science and mathematics are not viewed by research and policy as part of the scientific workforce or scientists. They do not necessarily need to have background in science and mathematics to teach these subjects.

13. Part of the explanation for negative attitudes and diminishing interests towards school science may be attributed to a shortage of well-qualified science teachers, particularly in physics, capable of providing a positive and effective experience. As the latest attempt to tackle the shortage of qualified teachers the Government is now urging companies to encourage career switchers amongst their scientific workforce to take the leap and go into teaching. A new programme called the 'Transition to Teaching' programme, launched in the spring 2008, linking the teacher training agency with employers, aims to encourage science experts to consider teaching as a second career. Why so much emphasis on young people to become future scientists and engineering, and then trying to attract them to become science teachers. Why not try to inspire children from early age to consider teaching science as a viable future career option. Initiatives are needed to promote teaching STEM science at schools as a rewarding and attractive career options amongst young people.

Section 6.6: Some General Observations and Comments

1. On 13 March 2007, a one day event, entitled, 'Role Model Platform for Young Scientists' took place at Newcastle University, as part of the ESRC Festival of Social Sciences, to disseminate the findings of this Research Synthesis. The event aimed to inform, raise awareness and promote the take up of science initiatives, grants, awards and bursaries amongst local schools and colleges (science teachers and pupils). The issue of the lack of a comprehensive directory of STEM initiative was discussed. The recommendations made by this report with regards to the need for the development of a comprehensive web-based directory

or user guide that brings together information about STEM initiative under one single source was very much welcomed by the school representatives. However, the following comment was made by SETPOINT Co-ordinator in Northumberland, one of the representatives on the Q&A expert panel at the event. *'Directories in the past have been difficult to maintain, new schemes happen all the time, old schemes run out of funding, remits for others change. As a result, one directory is a very difficult thing to put together. It can also be daunting for a teacher to pick one up, when it's likely to contain information about 500+ schemes. For example, there is a Shape the Future brochure has more than 70 schemes, and this is just for Engineering .... That's why the SETPOINTs are here in as a contact point for schools; they can telephone and ask us about them. We also go and visit schools to discuss schemes',*

2. The Q&A Panel Session, held as part of the above event, was chaired by Geoff Clack, Education and Training Manager, EEF's Northern Association. Geoff is a real champion, he has played a pivotal role in the promotion, raising awareness, organisation and judging of the British Formula One in schools scheme at regional, national and international levels. He is always willing to take part in any activities aimed at promoting science and particularly engineering amongst school pupils at all ages. He tuned the last Year F1 in Schools North East region into a major engineering fair. He has kindly given us permission for the use of F1 photos for the front cover of this report. His expertise and dedication have helped many youngsters in the North East to develop projects and achieve regional, national and international awards in the science and engineering fields. He is also actively involved in other STEM schemes such as Greenpower, British Young engineering, BA Crest Awards, etc.

3. On 1 July 2008, we were invited by Geoff Clack to attend the Young Engineers Awards North East Final at Sunderland University. The event provided an excellent opportunity to the finalist to showcase their projects. We held discussions with a number of pupils about their projects and impact on their further education and career. The pupils were all so excited, enthusiastic and proud of their achievements. Three young boys had developed a water purifying system sponsored by a local manufacturing company. Two of them were on an engineering diploma course at their local college and had secured places at Newcastle University to undertake undergraduate degree in engineering. They also had been offered placement opportunity from the sponsored company to spend a year to work at the company and to gain industry experience before going to the university. 'What a great opportunity to take a gap year', they said.

They also said that the project was part of their course work and that they spent some of their time at a local Science Club to develop their project. They were determined to follow up science and believed the competition had helped them a great deal to gain more practical experience, as well as providing them with the opportunity to work together on a joint project. The event was sponsored by local universities and employers.

There are several lessons to be leant from these observations:

First: This Research Synthesis was based, solely, on desk research. The above comments clearly demonstrate the need for a more comprehensive study that involves consultation with STEM initiatives' representatives, participating schools, teachers, pupils, parents and other sponsors and partners. It is only through such investigation that insight can be gained about the initiatives, how they work in practice and their real contribution to STEM education.

Second: The Mapping Review 2006 has recommended that 'no more than ten national schemes of STEM support for schools (excluding national teacher supply measures) that should receive national funding and endorsement, and has commented on how particular existing schemes and funding streams should be rationalised to fit within this simpler framework, building on those which can contribute most to achieving our objectives at national level'. There is a danger that, in the light of the comments made above and in the absent of a comprehensive investigation, the real impact and contribution of some really effective local, regional and national initiatives and schemes may be overlooked and prevent them from receiving future funding, leading to their demise before their real contribution and impact is recognised and appreciated.

Third: The Mapping Review 2004 highlighted the existence of numerous local initiatives with small scale funding which may have a localised impact on raising attainment and improving the quality of teaching. The review commented that these initiatives may make an impact locally, but questioned whether they have any major impacts in achieving Government's objectives at the national levels. The above observations suggest that local initiatives may indeed be more effective than national initiatives as they are more likely to be sponsored by local universities and initiatives, as well as local employers. They are also more likely to meet the needs of the local community.

However, there is a need to provide links between local and regional initiatives across the UK in order to share and exchange good practice.

Fourth: There is need to identify champions such as Geoff Clack who are not simply acting as role models and mentors but are actively involved in the promotion of STEM schemes and initiatives. It is important to acknowledge their contribution and achievement more widely, in order to encourage more champions into the scientific fields.

STEM Directory Project
(A recent development since the production of this report)

The Research Synthesis report was produced and submitted to the ESRC/DCSF in July 2008 for approval. The final version was submitted in October 2008. This report acknowledges that, since the production of this report, the STEM Directory project was established to provide an unique opportunity for the science, technology, engineering and maths communities to come together to meet a common objective. The STEM Directory project is led by a strategic management group of key organisations in the UK STEM Community, including, SCORE, ACME and the Royal Academy of Engineering, and is supported by the Department for Children, Schools and Families (DCSF) and the Department for Innovation, Universities and Skills (DIUS).

One major outcome of the STEM Directory project is the production of three separate directories, namely, Science, Engineering and Technology, and Mathematics. Launched in September 2008, the directories aim to serve the needs of science, mathematics and design and technology teachers across the UK. The directories set to improve coherence and coordination of STEM schemes and activities. They provide STEM teachers and lecturers with a reliable and comprehensive overview and signposts to enrichment and enhancement activities across the UK. The directories can be viewed and downloaded as pdf files. Hard copies can also be obtained from the STEM directories website (source: www.stemdirectories.org.uk).

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ANNEX 1

Improving Take-Up of Science and Technology Subjects in Schools and Colleges

An overview of some key STEM organisations and initiatives

Gender Specific Schemes

Organisation: WISE (women in science, engineering and construction)

Initiative: Role models, WISE outlook and Insight

Date / reoccurrence: On-going

Eligibility: WISE is currently prioritising 11-14-year-olds girls, however the Insight scheme is open to those of a college age

Aims and short description of the project: The WISE campaign collaborates with those from industry and education to encourage girls of school age to value and pursue STEM or construction related courses and move on into related careers.

WISE operate a role models scheme to allow young girls to get an insight in to careers in science, engineering and construction. WISE also offers a range of publications such as magazines for girls (SPARK, Girl Like You) to booklets for teachers and parents (Engineering Equals). The WISE Outlook programme is a three-day programme run at local colleges, enabling Year 9 girls to experience engineering first-hand. The girls take part in hands-on engineering projects, designing and making something for themselves, work in teams to develop presentational skills, talk to women students and staff from technical colleges and meet women engineers to talk about their work and careers. Insight is aimed at those who are interested finding out what it takes to become an engineer. Girls are able to spend a week at a university and get the opportunity to find out about different fields of engineering, spend a day with an engineering company and meet other women who have studied and are making successful careers in engineering.

Each year the WISE campaign present three prestigious awards in recognition of companies and individuals who have actively addressed the issue of promoting science and engineering to young girls and women, and who have supported the aims of WISE.

Impact: Through its initiatives, the campaign has helped to double the percentage of female engineering graduates from 7% in 1984 to 15% today. To date however there has been no onward tracking of participants from the WISE outlook programme, or reporting on trends in uptake or college participation.

Reference and contact details: http://www.wisecampaign.org.uk/

WISE, 2nd floor Weston House, 246 High Holborn, London, WC1V 7EX, Tel: 020 3206 0408

Organisation: UK resource centre for women in science, engineering and technology (UKRC)

Initiative: Wider Horizons work placement scheme

Date/reoccurrence: On-going

Eligibility: School age girls

Aims and short description of the project: The Wider Horizons work placement scheme provides two or three-week placements for girls in non-traditional jobs. The aim is to provide girls with alternative career knowledge and experience, ensure they can assess their career options with greater objectivity, increase their awareness of the opportunities available, stimulate their interest in science, engineering, construction and technology, and build their confidence and skills through challenging and interesting placements. As well as providing placements for girls in science, engineering, construction or technology, placements are also offered to girls who ask for clerical or administrative work experience. These girls are also offered placements in science, engineering, construction or technology companies and the placement allows them to experience clerical work while also learning about other types of work within the sector.

Impact: Specific evaluations are not given

Reference and contact details:

http://www.ukrc4setwomen.org/html/education/schools-and-stem/

UK Resource Centre for Women in Science, Engineering and Technology - Listerhills Park of Science and Commerce - 40-42 Campus Road - Bradford - BD7 1HR

Organisation: Bradford College

Initiative: Lets TWIST (Train women in science, engineering, construction and technology)

Date/reoccurrence: Event details are shown for 2003 - 2005

Eligibility: Events are organised for girls of school age and courses are available to be taken by women

Aims and short description of the project: Lets TWIST aims to ensure women's long term participation in construction and technology training and occupations. The schemes they offer are targeted at encouraging girls to understand and get excited by engineering. Specific examples include education and training courses and a mentoring program linking young girls to women in industry. "Get girls into construction" is a one day workshop for a group of 15 year 9 pupils from 3 different schools. They are paired with female role models who worked in construction and are able to visit a construction site in Bradford.

Impact: Specific evaluations are not given

Reference and contact details:

http://letstwist.bradfordcollege.ac.uk/index.htm

Jeanette McMurdo, Let's TWIST, Department of Engineering & Construction, Bradford College, Rm 255, Randall Well, Great Horton Road, Bradford BD7 1AY, Tel: 01274 438978 or 01274 433113

Email: j.mcmurdo@bradfordcollege.ac.uk

Organisation: Eciste – UK (sciZmic) with Girlguiding UK

Initiative: Science badge and scientific experiments

Date / reoccurrence: On-going

Eligibility: Girls who are members of rainbows, brownies and guides

Aims and short description of the project: Girlguiding UK is the UK's largest organisation for girls and young women with over half a million members aged 5 – 25. SciZmic, the science discovery clubs network, is working in partnership with girlguiding UK to host events across the country to give girls hands on opportunities of scientific experiments allowing them to view science as fun.

They have developed the "Go for it! Experiment" and "Go For It! Space", a new science badge that come with leader support materials. Promotional events have reached over 7000 girls around the UK. Funding from the Institute of Physics has also helped to extend the project further to update and refresh the Brownie Science badge and create new website activities. During the Go For It! SciZmic Space events guides carry out experiments based around five zones of healthy lifestyle, global awareness, discovery, skills, and relationships and celebrating diversity.

Girlguiding UK Head of Guiding Development Jennie Lamb said: 'This partnership has been a wonderful way for Girlguiding UK's members to enjoy finding out about science outside the classroom and is a great opportunity for girls of all abilities to develop and discover something new.' Dr Louise Webb from SciZmic said: 'Science, engineering and technology are still thought of by many as male only domains. Think of all the talent and creativity those subject areas are currently missing!

Impact: Specific evaluations are not given

Reference and contact details: http://www.girlguiding.org.uk/

General enquiries: 0207 834 6242

Organisation: Northumbria University, School of computing engineering and information sciences

Initiative: Girls in computing, engineering and information science

Date/reoccurrence: 28th November 2007

Eligibility: Girls who want to study computing, engineering and information science

Aims and short description of the project: It is a special session organised just for girls to show that those areas are accessible to them and offers excellent career prospects. The university wants girls to attend the event and meet other female students, listen to guest speakers and to view the facilities.

Impact: Specific evaluations are not given

Money available: Workshop put on by the university

Reference and contact details:

http://northumbria.ac.uk/sd/academic/ceis/events/454667

Telephone number for enquiries about the course: (0191) 227 4342

Science and Discovery Centres (SDCs) in the UK

Science and discovery centres (SDCs) were introduced to the UK in the early 1980s. Their growth in number and popularity world-wide is claimed to be one of the educational success stories of the last 25 years. In the UK, the science and discovery sector has expanded on an unprecedented scale through Millennium Commission investment of £250 million, matched by equivalent funding and sponsorship from other public and private sources, including for example, the Wellcome Trust and the National Lottery Fund.

Today there are over 40 science centres in the UK and a similar number of discovery centres in museums, botanic gardens, aquariums and zoos, attracting over 11 million visits each year.

Science centres are fundamentally educational institutions. They have informal education at the heart of their missions, and in relation to the formal education system they provide support for teachers and enriching experiences for pupils.

The excellence of science education formally in school and informally through SDCs is key to ensuring a flying start for all children It has been claimed that SDCs are potentially very significant contributors to the future supply of scientists and technologists.

In relation to their approximately 11 million visitors each year, the science centres contribute and reinforce the National Curriculum, particularly, in the areas of science, technology, engineering and maths (STEM), by providing interactive and hands-on experience and actively contributing to the 'education and lifelong learning' goals of both Westminster and the Governments.

The SDCs aim to develop high quality curriculum materials and training provision which can be offered to pupils, teachers and other agencies, thereby generating income and contributing towards the sustainability of the centre.

The STEM Review report made little mention of SDCs' contribution to science education and suggested that the centres are viewed by the formal sector, to be on the 'periphery of science education'. The report highlighted the need to improve the integration of formal and informal learning, and to support links between the Science and Discovery Centres and formal education programmes.

As a result, in 2006, Welcome Trust commissioned CRG Research Ltd to undertake an independent evaluation of the five Wellcome Trust-funded Millennium centres, 'At-Bristol'; 'Birmingham ThinkTank'; 'Dundee Sensation'; 'Glasgow Science Centre'; and the 'Newcastle International Centre for Life'

The report concluded that Science centres have a key role to play in delivering informal education they could play a more proactive role in integrating formal and informal learning. Furthermore, the report found that the five centres act as regional "hubs" for science based activities, providing "extensive educational resources to local schools".

The report commented that Science centres are able to offer a very different learning experience to that of the classroom. The majority of teachers who participated in their impact assessment spoke positively about the science centres, commenting that their trips helped to create a positive attitude towards science amongst pupils it highlighted the fact that the main focus of SDCs is on supporting formal education for primary schools and children aged 7-11 years old. Although secondary school audiences are also important to the science centres, the evaluation found that it appears to be more difficult for the centres to support formal education for secondary schools, mainly because of difficulties with school timetabling and the need for clear curriculum links.

Despite the substantial investment in science centres at the turn of the Millennium, a new report, the Funding of Science and Discovery Centres, says that centres now face serious cash crisis. Two of the centres which were funded by the Millennium Commission - Doncaster's Earth Centre and Ayrshire's Big Idea - have already closed and At-Bristol had to close two of its three attractions and has made 45 staff redundant. Interactive exhibits are particularly expensive to maintain, and the need to update displays regularly to reflect the rapid pace of change in science and technology adds further pressures. One of the key concerns is that a number of centres are increasingly forced to respond to immediate funding opportunities and, consequently, may be forced to diversify their activities. The report says that without a change in their current financial circumstances, they will be closed before their value has been properly assessed and recognised. (source, www.ecsite-uk.net)

Science Learning Centres

Science Learning Centres are a national network for professional development in Science Teaching. The Centres support teachers in enhancing their professional skills by providing them with opportunity to learn more about contemporary scientific ideas and in experimenting with effective teaching approaches and gaining experience of modern scientific techniques.

The prime purpose of the SLCs is to improve science teaching, raise morale in the teaching profession and to inspire pupils by providing them with a more exciting, intellectually stimulating and relevant science education, enabling them to gain the knowledge and the understanding they need.

There are nine regional Centres in England and one National Centre to serve the UK as a whole, each with a main base, as well as plans for Satellite Centres and online resources which can be accessed by teachers from across the country.

The Centres offer courses in the latest scientific research and industry, as well as education initiatives across all key stages and Post-16, to science teachers, technicians, FE lecturers and teachers tackling the ethics of science in society e.g. citizenship teachers.

Each of the Centres is equipped with new laboratories and ICT resources to provide advanced training. They are working with leading scientific organisations and businesses to ensure that the content delivered to the teachers is contemporary and relevant.

Science Learning Centres provide the highest quality Continuing Professional Development for everyone involved in science education, at all levels. With a network of ten Centres across the country access to innovative and inspiring courses is within easy reach.

Each appointed Science Learning Centre is developing its courses in consultation with the DfES and Wellcome Trust matching the criteria laid down at the appointment of each Centre. The criteria stipulate that the courses must:

- be for teachers, technicians and others involved in school science education in schools and colleges
- cover all areas of science at all Key Stages and post-16
- cover all areas of science
- underpin the science knowledge required in specialist vocational courses and associated subjects such as mathematics, statistics, technology, medicine, engineering and ICT studies
- include provision to teach the social and ethical aspects of science and its effect on our lives and Citizenship in general
- cover all areas of science at all Key Stages and post-16,
- update teachers' knowledge and skills in traditional areas of science education while also addressing contemporary topics and social issues

Science, Technology, Engineering and Mathematics Network (STEMNET)

http://www.stemnet.org.uk/

STEMNET aims to increase the take up of science at all levels from schools to careers and ensures that future generations are properly informed about the science and technology that surrounds them.

Working closely with its partners, STEMNET achieves this in two ways:

- By bringing science, technology, engineering and mathematics activities, experiences and excitement into classrooms throughout the UK, enhancing and enriching the national STEM curriculum

- By linking those companies and other organisations that employ STEM educated people, and schools, in such a way that young people can get a clear idea of the of the diverse and exciting range of careers available to them

Since 1996 the core funding of STEMNET has come form the Department of Trade and Industry, as well as support from the DfES. As a national organisation, it endeavors to ensure that no region of the country is disadvantaged, by comparison with any other, with respect to STEM opportunities.

STEMNET Mission Statement is:

'Through partnership working, make an impact on the educational added-value and career choices of all young people, by demonstrating to them, their teachers and other appropriate professionals, the relevance of STEM in today's world and the superb opportunities it offers'.

SETPOINTs

http://www.stemnet.org.uk/setpoints.cfm

STEMNET supports SETPOINTs financially by distributing core funding raised from government. By awarding contracts and monitoring Business Plans, STEMNET quality assures SETPOINTs and promotes best practice amongst them.

SETPOINTs are hosted by specially selected organisations skilled in facilitating links between education and the wider STEM community and working with other STEM partners. Hosted by a diverse range of organisations, operating at a local level, SETPOINTs can provide access to high quality meaningful activities and schemes for students and schools.

SETPOINTs have responsibility for an assigned area, which controls the number of schools and colleges they work with, ensuring the highest quality of service and a more personal and efficient channel of communication. This also enables them to respond to specific local and regional needs, whilst maintaining focus and ensuring alignment with national curriculum changes and requirements.

The Science and Engineering Ambassadors (SEAs) Programme

The Science and Engineering Ambassadors (SEAs) Programme is STEMNET's flagship programme. Ambassadors are individuals from a wide variety of STEM backgrounds, from all across the UK, who offer their time, enthusiasm and expertise to help schools inspire young people.

Ambassadors' backgrounds can range from marine biologists to mathematicians studying climate change, aeronautical engineering apprentices to medical physicists and industrial chemists to electrical engineers, to lab technicians and more. They represent over 1000 different employers, from large multi-nationals to SMEs and other organisations like the NHS, and the Environment Agency. Many SEAs are also undergraduates, studying at universities across the UK. These individuals act as invaluable role models to students, through the work they do in schools.

Anyone who has an interest in STEM and a desire to inspire children and young people in STEM subjects can become a SEA. The main qualities all ambassadors share are enthusiasm and commitment, along with a passion for what they do.

Funded by the DTI, the programme has grown rapidly and STEMNET now works with over 17,500 Ambassadors, with plans to expand this to 18,000 by the end of March 2008. STEMNET welcomes volunteers of all ages and backgrounds.

Association for Science Education (ASE)
www.ase.org.uk

The ASE is the UK's largest professional association for teachers of science. It was formed in 1963 as the merger of the **Science Master's Association** and the **Association of Women Science Teachers**. The origin of ASE can be traced back to 1900 following a letter written by four science masters from Eton College proposing a conference for Science Masters in Public Schools. Interestingly, one of the issues raised in the letter - as now - was *"the attainment of at least some clearer method of the teaching of Natural Science than exists at present, and .... by taking united action, do something towards emphasising the value of Science as a means of education".* The first Annual Meeting was held in January 1901 which then led to the formation of **the Association of Public School Science Masters (for more information about the history of ASE see '*Interpreters of Science'*** by David Leyton).

ASE is a publisher. As well as its main journals, Education in Science, Primary Science Review, School Science Review and Science Teacher Education, ASE publishes about 10 new titles a year available on a dedicated website. ASE has some 20,000 broad spread of members from primary and secondary teachers, to technicians, those involved in Initial Teacher Education and some 3500 of members are students.

The main objective of ASE is to improve the teaching of science and promote science education. Its Trust Deed goes on to elaborate on the Objects of the Association which includes promoting education

- by providing an authoritative medium through which the opinions of teachers of science may be expressed on educational matters and;
- by affording a means of communication among all persons and bodies of persons concerned with the teaching of science in particular and education in general.

African-Caribbean Network for Science and Technology

The African-Caribbean Network for Science & Technology (ACNST) was set up in 1995 by Black professionals working in Science, Engineering and Technology (SET) fields, to work for the advancement of African-Caribbean youth and adults in SET education, skills and careers. The ACNST works in partnership with schools, parents, Local Education Authorities (LEA'S), FE colleges, Universities, Industry, the statutory/voluntary sectors in SET promotion, and relevant government agencies/departments, in the delivery of its objectives.

The scheme also links African-Caribbean students with Black professionals working in the various fields of SET, so that they can serve as positive role models in raising the aspirations of these students.

Activities of the ACNST include: the Ishango Science Clubs, the National RESPECT Campaign, Cosmic Africa and the Delivering Inclusion in Science Communication (DISC) project.

The ACNST is a partner in the London Engineering Project (LEP), which provides the opportunity for ACNST to work in partnership with other Science, Technology, Engineering, and Mathematics (STEM) promotion organisations, to deliver a truly ground-breaking initiative mainstreaming gender and cultural diversity at its core, and establishing a sustainable legacy of good practice, which will not only transform the gender and race equality landscape of STEM achievement/aspiration/progression in the LEP schools, FE Colleges and Universities, but also in the partner organisations in the LEP.

Royal Society – Their Role in Supporting STEM at Schools

Founded in 1660, the Royal Society of London for the Improvement of Natural Knowledge – known simply as the Royal Society, is the UK's independent scientific academy dedicated to promoting excellence in science. The society motto "Nullius in Verba" meaning "on the words of no one" represents its commitment to establishing the truth of scientific matters through experimental work rather than through the citation of authority.

Education

Education is high on the Royal Society's agenda, stemming from a belief that knowledge of science and mathematics is important to succeed in life. Lord Martin Rees, Royal Society president, reiterates such opinions in his 2006 forward with comments such as: "our top priority must be to nurture and support those who will be the leaders of UK science 20 years from now….Science and Mathematics education is crucial. The future strength of the country is dependent on our school, college and university students being inspired by the prospect of pursuing careers in science and technology".

A key aim of the Royal Society is to promote education in the sciences and actively engage the public in scientific issues. A report commissioned by the Royal Society entitled "Increasing the Uptake of Science Post 16", recapitulates a conference that was held by the Royal Society addressing concerns regarding the dramatic decline in the numbers of young people opting to pursue A-levels in the physical sciences. Over the past 15 years a decline has been seen in A-level entries for physics (35%), maths (22%) and chemistry (13%). The report outlines key strategic priorities for the government and its agencies, and specific actions to be taken. Of particular interest to this research will be the data published on the uptake of science AS-levels which will help to increase understanding of the conversion between key stage 4 science and A-level entry. Another beneficial outcome is that experiences and good practices of science teachers in schools that are successful in promoting the take-up of science subjects will be shared within the teaching profession. Key note speakers (Professor John Howson & Dr Almut Sprigade and Professor Jim Donnelly & Professor Edgar Jenkins) delivered the following important messages:

- Despite a rise of 14% in the total A-level cohort between 2001 – 2005, the number of entries in chemistry and physics fell by 2.1% and 14% respectively.
- The uptake of science and mathematics post 16 will depend heavily on the availability of sufficient numbers of well qualified teachers.
- A prominent government reform is the specialist schools system with over 300 designated specialist science colleges.

Lessons by example

The conference proceedings highlighted 3 case studies of schools where a substantially higher than average proportion (over 45%) of students go on to study at least 1 science post 16.

- The Thomas Hardye School, Dorchester – uses powerful mottos to create a success culture and has a strong pastoral system. All 25 science teachers are subject specialists and the comprehensive intake obtains 83% A* - C GCSE grades. Science clubs are run after school, students are monitored and feedback is given regarding work. Students go on to take A-level science subjects due to the positive experience they have had at the secondary school.
- Parkstone Grammar School – is an all girl's school with labs that are in short supply, some of which haven't been refurbished since the 1960s. Students continue to do science A-levels even though it may not be their strongest subject due to the support and approachability of the department. It has its own pastoral system where pupils from year 8 upwards are able to enter the central department office and approach teachers.
- The Kings of Wessex Community School – is a specialist technology centre for 13 – 18 year olds. At AS/A-level: biology, chemistry and physics are in the 5 most popular subjects with approximately 60% of students taking at least 1 science subject. Students cite the facilities as an important part of why they like science.

Teachers teach almost exclusively within their specialism which gives continuity and self-confidence to the students.

Partnership Grants

The Royal Society receives £30 million from the UK government each year, some of which is used to fund the Partnership Grants scheme. The scheme began in 2000 with the aim of supporting activities that link practising scientists and engineers with schools. This enables the pupils to gain experience within the field of scientific investigation and work on projects with science professionals that are relevant to their lives. The scheme partners teachers and, scientists and engineers working in industry to allow them to undertake stimulating, creative and exciting projects. The teachers are in charge of running the school science projects in which their students collaborate with the scientists or engineers. The scheme offers grants of up to £3000 for primary and secondary school pupils (5 – 18 year olds). The Partnerships bring benefits to all parties involved, enabling: teachers to increase their scientific knowledge, scientists and engineers to develop their communication skills and engage with younger minds, and pupils to get a snapshot of what a career in science and technology could involve.

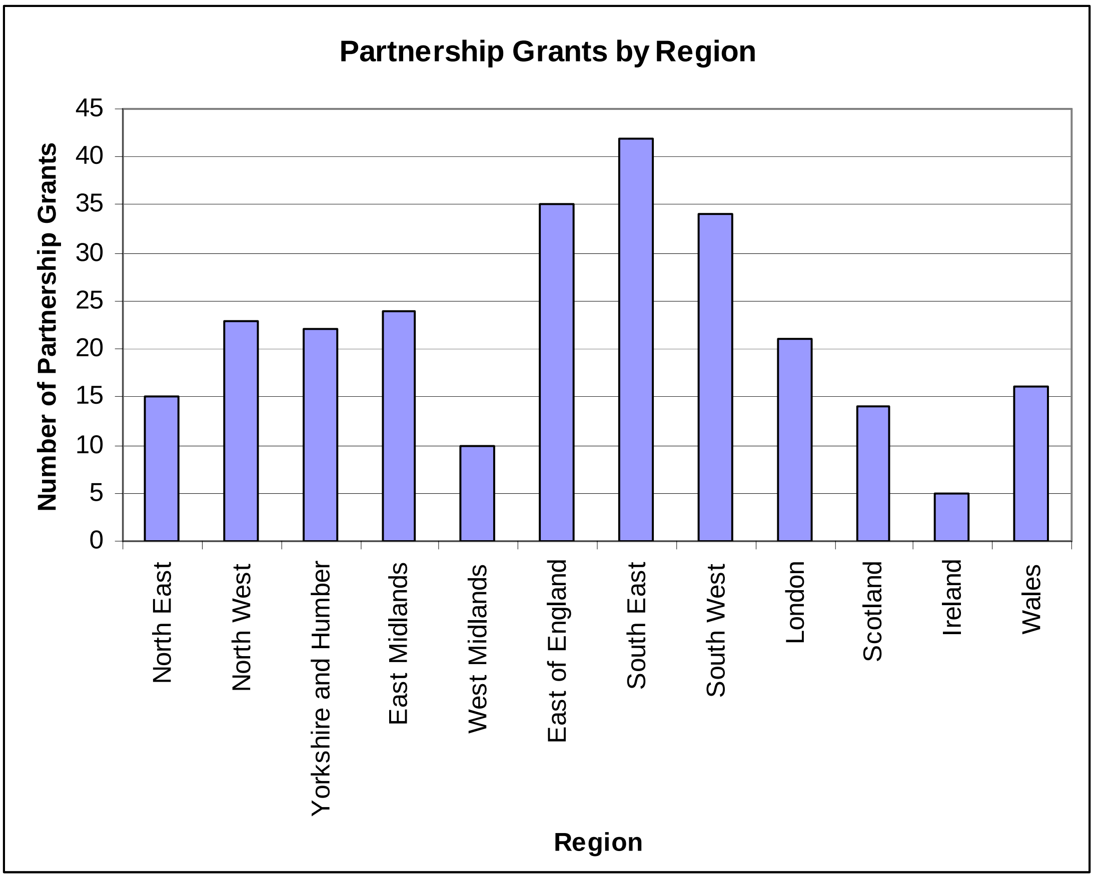
Primary Schools

The 261 grants awarded to primary schools in England, Wales and Scotland with available information have been analysed to identify any key trends, with the school location and high achieving schools forming the focus. The results are as follows:

- **Regional Breakdown**

When the number of Partnership grants allocated are divided up by region we see the most grants allocated to the South East (42) and the East of England (35), as shown in Graph 1.

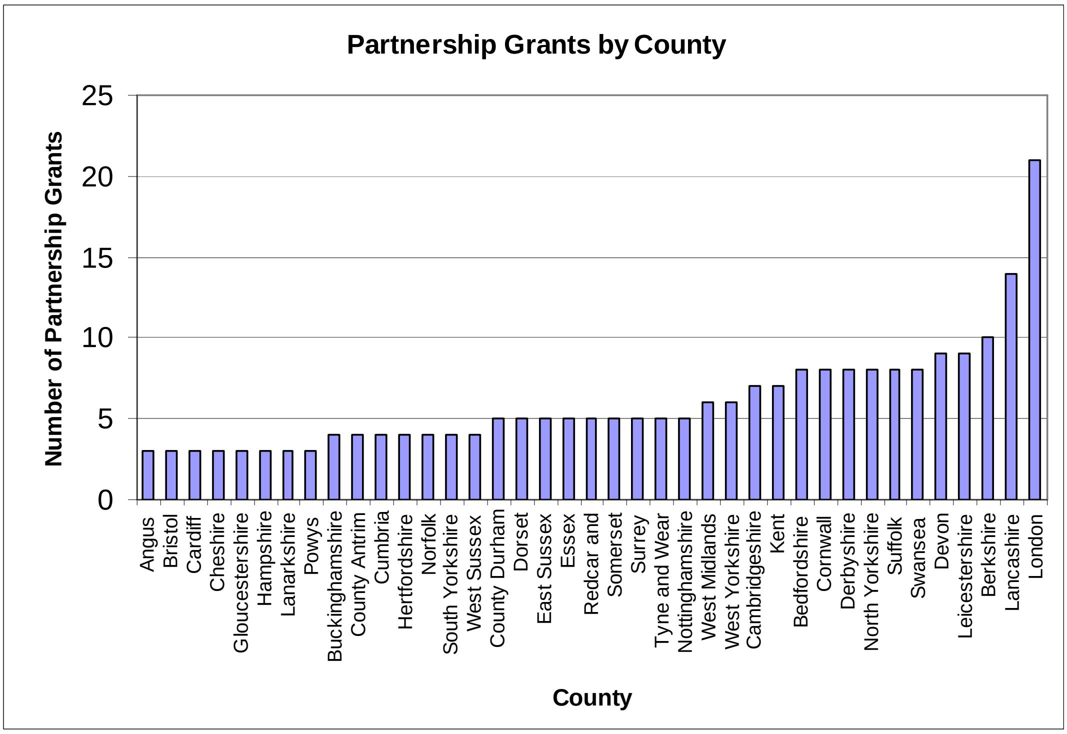
Graph 1: The Number of Partnership Grants Obtained, Expressed by Region (total number of grants = 261)



- **County Breakdown**

In total 14 counties account for 50% of the grants, the county with the most partnership grants are: London (8%), Lancashire (5%), Berkshire (4%), this is represented in Graph 2, counties with less than 3 grants have been excluded from the graph.

Graph 2: Total Number of Partnership Grants by County (excluding counties with less than 3)



- **High Performers**

There are several schools who have had repeated success in obtaining partnership grants. They are, by county:

London (obtained 21 grants in total)

2 grants went to Larmenier and Sacred Heart RC Primary School, London with Charing Cross Hospital, London. The school was awarded £2070 in 2003 for "Investigating Micro-organisms in the Environment" and £2500 in 2004 for "Investigating mixtures, suspensions and emulsions".

Lancashire (obtained 14 grants in total)

3 grants went to Deeplish Primary School, Rochdale. In partnership with Jodrell Bank Observatory, Deeplish Primary School was awarded £880 for "The Skies" in 2003. They were also awarded £1,640 for "Fit for Life" in 2002 working in partnership with North Manchester Health Care Trust, and £1972 for "Fit for Life" working in partnership with Manchester University in 2001.

Sparrow Hill Community Primary School in Rochdale also received a grant for £2,389, possibly suggesting networking of teachers in the area.

Berkshire (10 partnership grants obtained in total)

5 grants were awarded to Herries School, Maidenhead, 4 of which in partnership with the Royal Holloway, University of London and 1 with Department of Meteorology, University of Reading.

Herries School was awarded: £340 for "Our playground the Microcosm" in 2001 using the school grounds as an analogy of planet Earth to investigate at first hand the links between weather, environment and ecology; £490 for "Stag Beetle Habitat Research" in 2002; £550 for "Stag beetles and fungi" in 2003; £280 for "A bucketload of beetles" in 2005 and £966 for "Future Fruiting Fungi" in 2007.

Bedfordshire (8 partnership grants obtained in total)

3 grants went to Pulford Church of England VA Lower School, Leighton Buzzard, 2 of which were in partnership with Vision Systems (Europe) Ltd, Leighton Buzzard and 1 with Petards Vision Ltd.

The school was awarded: £2,225 in 2002 for "Pulford Power" - an investigation into the generation and use of renewable energy resources; £1,300 in 2003 for "Pulford Irrigation - a design and build project to install an automatic irrigation system powered by renewable energy" and £1,810 for “Machines and Robots in Action” in 2005.

2 grants went to Ashton Middle School, Dunstable with GlaxoSmithKline, Stevenage. Ashton Middle School was awarded £2,200 in 2001 for "Science in the real world - a lower/middle school liaison project" and £2,000 in 2003 for "Chemistry for all" - working to understand the concepts of physical and chemical changes.

There was one other grant obtained at a school in Dunstable, which may signify networking of teachers.

Swansea (obtained 8 grants in total)

1 grant went to Brynhyfryd Junior School, and another grant went to Brynhyfryd Infant School; both schools were working in partnership with the Environment Centre, Swansea. The Junior School was awarded £1600 in 2002 for "Mini-beast and wildlife reserve" - establishing a small meadow area within the school grounds to attract wild birds, insects and mini-beasts using natural wild flowers and trees. The Infant School was awarded £2250 in 2003 for "Environment/Science: Mini-beast and Pond-life reserve".

Nottinghamshire (obtained 5 grants in total)

2 grants went to Whitegate Primary School, Nottingham with The Nottinghamshire Wildlife Trust, Nottingham. The school was awarded £2500 in 2001 for "A Sensory Maze for School

and Community links" - design, build and development of an interactive sensory garden and £2044 in 2003 for "Creating and Investigating Habitats".

<u>County Antrim (obtained 4 partnership grants in total)</u>

3 grants went to Eden Primary School, Carrickfergus, County Antrim, 2 of which with FC Wilson Engineering and 1 with AES Kilroot Power Station. Eden Primary School was awarded: £1100 for "Electricity and the Environment" in 2003; £250 for "Kilroot Power Station and its impact on Eden Village" in 2001, and £1300 for "Making electricity around the world" in 2001.

Cairncastle Primary School is in close proximity to Eden Primary school and worked in a similar field to that of Eden Primary School with a project entitled "Electricity at work" for which they were awarded £480 in 2002. This may be indicative of networking within the area.

<u>Gloucestershire (obtained 3 grants in total)</u>

2 awards went to Sharpness Primary School, Berkeley with Just Ecology Ltd, Berkeley.

An award of £2035 in 2003 was made for "Opening the window on biodiversity", and a further £940 in 2003 for "Opening the window on biodiversity - phase 2".

- **Which teachers and professionals are receiving the grants?**

It maybe the case that where schools are receiving more than one partnership grant, they are being awarded to the same teacher, where data is available this seems largely apparent, however it is important to note that data is only available for a limited number of awards.

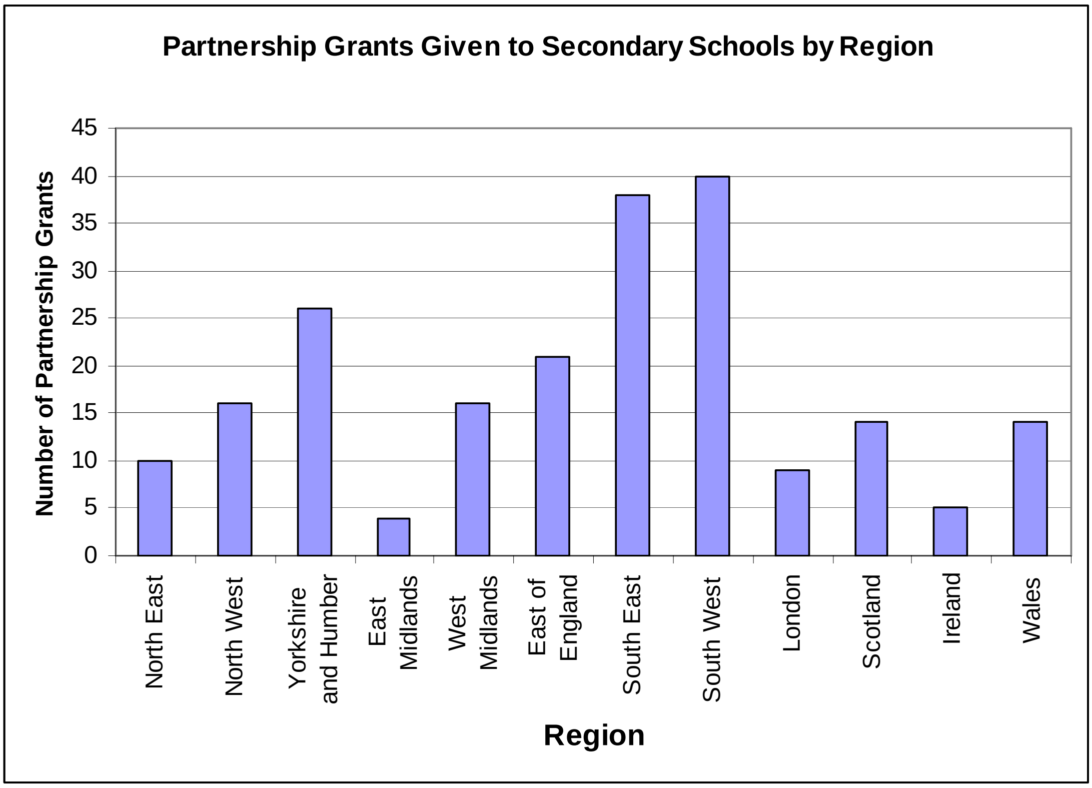
<u>Secondary Schools</u>

The same process was applied to the data provided for the secondary schools, in total 212 secondary schools were included in the analysis.

- **Regional Breakdown**

The South East and South West received the most partnership grants. The high proportion of Partnership Grants in the South East mirrors the primary schools findings; however, there are dramatic differences with most of the other regions, particularly the East Midlands, which has a low level of grants in comparison to the findings of the primary school data. The South West is proportionately higher than that of the primary school data (Graph 3).

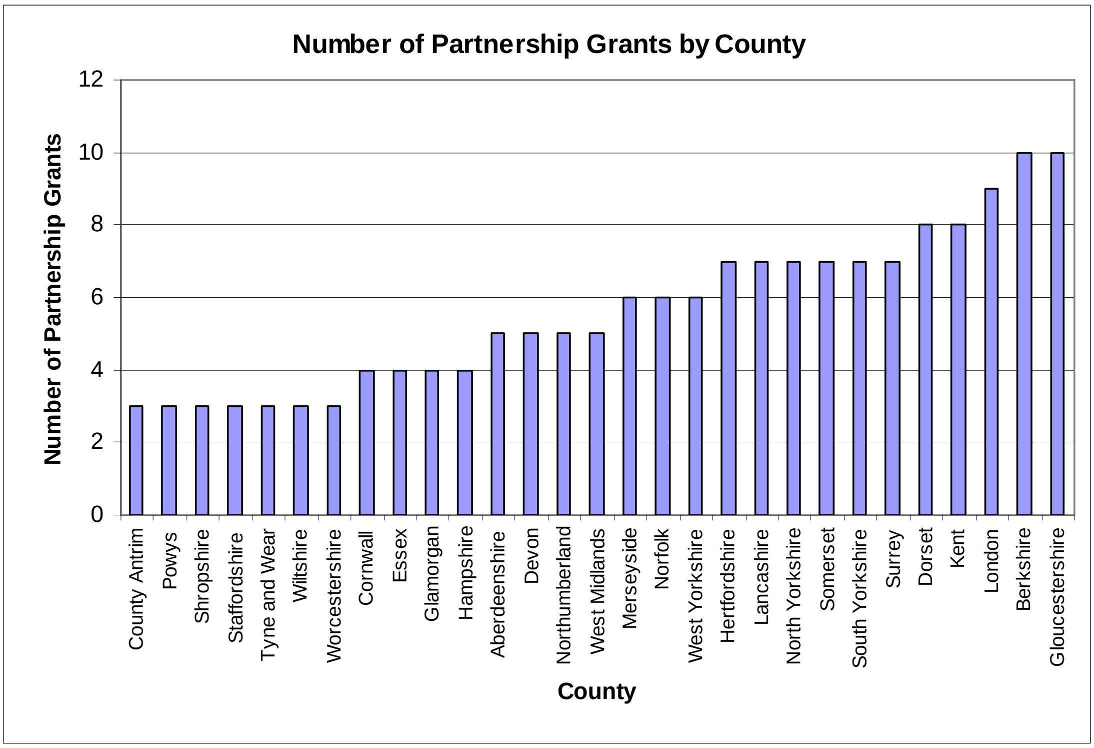
Graph 3: Secondary School partnership grants by region (actual numbers of grants obtained: 212).



- **County Breakdown**

The county that has been the most successful in obtaining grants is Berkshire and Gloucestershire followed by London and then Kent and Dorset. The results are shown in Graph 4 below.

Graph 4: Secondary Schools Partnership Grants by County (excluding all counties with less than 3 Partnership Grants)



- **High Performers**

The schools obtaining more than one grant are shown below by county. In total there were 21 schools that obtained more than one grant, equating to just below one quarter of all grants awarded to secondary schools.

Bedfordshire

Lincroft Middle School, Bedford

In partnership with Raylin Ltd, Bedford, Lincroft Middle School was awarded £2,575 for "Assessing the traffic noise levels near school caused by opening a bypass". The school also investigated "Factors affecting the strength of brewed tea using light transmission" in partnership with Unilever Research and Development (Colworth), Bedford.

Berkshire

Burnham Upper School

3 grants went to Burnham Upper School, Slough. In partnership with Burnham Health Centre the school was awarded £2,995 for "Stress and blood pressure" in 2006. In partnership with Eureka they received £2500 for "Formulation of Fizzy Drinks" in 2005, and

£2,500 for "Working with microbes and cells" in 2005 in partnership with Lonza Biologics plc.

Denefield School

A total of £7,440 was awarded to Denefield School, Reading, through 4 grants. Working with npower Renewables £2,370 was awarded for "Manipulating the structure of living organisms through the ages", £1,685 was awarded for "Harvesting energy within our school grounds" working with the Education Liaison Officer CCLRC CHILTON DIDCOT and £1,700 was awarded for a "Technology and Arts Week" working with Microsoft Development Centre. In addition Lonza Biologics, who also worked with Burnham Upper School, Berkshire, were awarded £1,685 for "Harvesting energy within our school grounds" in 2004.

As with the primary schools, Berkshire received a significant number of grants, this may indicate networking between schools and teachers in both primary and secondary schools.

<u>Dorset</u>

Ferndown Upper School, Ferndown

In partnership with Centre for Ecology and Hydrology, Dorchester, Ferndown School was awarded £1,500 in 2001 for “Modelling gene transfer from GM Crops to neighbouring non GM crops” and £875 in 2003 for “Modelling Transfer of Pollen from GM Crops”.

Twynham School, Christchurch

In partnership with GED Design the school was awarded £506 for "Greenpower 2001: Electric Car Competition" and £1,595 for "Wind of change", both in 2001.

<u>Gloucestershire</u>

Deer Park School, Cirencester

Working in partnership with Airbus UK, Bristol the school was awarded £815 in 2001 for “The Science of Flying and Fairgrounds”. In 2004 they received £803 for “Building the perfect athlete” working with the School of Sport and Leisure, University of Gloucestershire. In partnership with the University of Manchester they were awarded £1,940 for “Hydrogen - Fuel of the Future?” and in 2007 they received £1,445 for "I Robot" working in partnership with BMW Swindon.

<u>Hertfordshire</u>

The Thomas Alleyne School, Stevenage

In partnership with GlaxoSmithKline, Stevenage, the Thomas Alleyne School received £2,386 in 2001 for “Science against Crime” and a further £982 in 2002.

London

Gumley House Convent School, Isleworth

In partnership with The Ram Brewery, Young and Co’s Brewery, London, Gumley House Convent School was awarded £2,085 in 2002 for “What makes a yeast cell happy?” and £1,344 in 2003 for “Continuation of 'What makes a yeast cell happy?'.

South Camden Community School

In partnership with Environmental Health Department, London Borough of Camden, London, South Camden Community School was awarded £2,485 for "South Camden Community School Science Garden - Environmental Monitoring Project" in 2005. In 2001 the school received £614 for "Applying science through curriculum links" working in partnership with the Royal Veterinary College, London.

Northumberland

Bedlingtonshire Community High School

3 grants went to Bedlingtonshire Community High School with the Construction Industry Training Board, Sunderland. They were awarded £2,475 in 2001 for “Bridges to the past - Highways to the Future” and £2,500 in 2001 for “Bridges to the past - Highways to the Future 2” and awarded £2,480 in 2004 for “I’m a castaway, get me out of here!”

Somerset

Writhlington School, Bath

In partnership with the Royal Botanic Gardens, Kew, 2 grants were awarded to Writhlington School. The school was awarded £1,520 in 2001 for “Raising Bee Orchids from seed for reintroduction” and £2,080 in 2004 for “Bringing orchid conservation research into schools”.

Worcestershire

King Charles I School, Kidderminster

In partnership with Birmingham’s Women’s Hospital, King Charles I school was awarded £2,380 in 2001 for “Biomedical Science, Drama, Art”, and awarded £2,500 in 2004 for “Growing British native orchids from seed” in partnership with Kidderminster College.

Yorkshire

Prince Henry's Grammar School, Otley

In partnership with the Division of Microbiology, University of Leeds, Prince Henry's Grammar school was awarded £1,925.34 in 2001 for "Compost Microbes as Potential Sources of Antifungal and Antibacterial agents" and £2,425 in 2003 for "The importance of urease in the nitrogen turnover of soils" working in partnership with the Faculty of Biological Sciences, University of Leeds.

- Which teachers and professionals are receiving the grants?

The impact that teachers and professionals are having on the numbers of grants obtained is very difficult to analyse as the names of the individual teachers that obtain the grants are not given. However, the number of awards given to the same schools indicates that teachers are either reapplying for grants or they are recommending that others within the school or area apply.

Further Education Resources

As well as the partnership grant, other resources are available for scientists, teachers and pupils that provide access to cutting edge research. Under the Acclaim initiative, an information pack is provided to teachers including information on the research and achievements of scientists, Acclaim is aimed at Key Stage 3 pupils. Volcano Island is a video created for 11 – 16 year olds, telling the story of the volcanic eruption on Montserrat. The summer exhibitions held annually bring teams of researchers and pupils together to discuss their work with members of the public. A partnership grant project involving Neatherd High School and the University of Cambridge was chosen to be the school's exhibit at the Summer Exhibition in 2004.

Role Models

Another scheme based at promoting science and engineering for younger pupils is the Role Models initiative. Within this initiative external science, engineering and technology professionals are placed in schools as role models. The importance of the scheme was highlighted by Sir Magdi Yacoub, "Helping young people to value the contribution of SET (science, engineering and technology) to their lives… hinges on those of us in the profession… Inspiring young people to take part in discovery and delivery of science is critical for the continued success of our economy". The host school can benefit greatly from such a scheme as teachers and pupils can develop skills and have access to resources not usually on offer and in many cases the role models presence promotes learning and reduces behavioural problems.

SCORE

The Science Community Partnership supporting Education (SCORE) was established by members of the scientific community concerned by some of the trends seen in science education. Members recognised the need to enhance science education and in particular to consider the decline in the numbers of young people taking chemistry and physics A-levels and the unacceptable shortages of specialist teachers in those areas. Some of the key members include leaders in the science and science education fields. With the focus being on team work, joint studies will be carried out and best practices identified and shared.

Chemistry at Work

The Chemistry at Work scheme is a Royal Society of Chemistry (RSC) initiative that has been running for over 10 years. It aims to show school students how chemistry is used in industry, research and everyday life. The aims of the scheme are:

- to present a positive image of chemistry and the chemical sciences to young people in schools and colleges
- to show the variety of work chemists do and how chemistry can be part of some jobs which it may not have been expected to be
- to show that chemistry is an important part of the economy and of the county
- to show that chemistry is an exciting and interesting way to earn a living
- to show that chemists are real people

These aims are achieved by holding events around the country which engage young people and organisations in the chemical and chemical sciences fields. The events offer school children the opportunity to appreciate the place of chemistry in everyday life and the world of work with a particular emphasis on what is happening in their local area. They highlight the positive image of chemistry as a rewarding and wealth creating activity. The events are not primarily careers events nor are they aimed at teaching students, but the RSC hope that the meetings will encourage students to consider a career in chemistry.

The events take the form of 1 – 3 day workshops and are held in conventional places such as colleges, universities and schools but also in more unexpected venues such as supermarkets. Organisations local to the event area are invited to present some aspects of what they do to children that visit. Typically groups of pupils will come to an event accompanied by a teacher and normally spend half a day taking part in the hands on activities and listening to presentations. The RSC estimated that 100 – 300 pupils attend each event every day and over a year, 350 different schools will have had pupils attending 1 of 50 events lasting 120 days in total. The events mostly target 13 – 16 year olds, but the RSC is keen to extend the events to those post 16 and those at primary schools. Any company whose main activity is chemistry or chemical sciences applications and those who use chemistry in a less obvious way give presentations. As such a very wide variety of professionals attend the events.

Benefits are wide reaching as the students are able to get first hand experience of chemistry in the real world from those people who are actually involved, teachers update their knowledge and make contacts with local industry, the companies are able to engage young minds and raise their profile with those who they may one day employ, and the organisers benefit from a raised profile. Organisers can include: education business partnerships and SETPOINTS, universities, college and school chemistry departments, RSC local sections and individuals.

The RSC is there to provide financial support and they fund to a maximum of £550 per day. They employ a national coordinator (John Payne) who supports local sections and the society provides help with contacts and organises training schemes for participants to help them make successful presentations to younger people. The presentations are interactive and hands on as much as possible and allow small groups to take part in them.

Identification of key trends

The RSC website gives a list of the previous and forthcoming events. The previous event (November 2006 – November 2007) data has been analysed in terms of the host venue location. The website provides specific information on 59 events – 10 of which where held by non academic hosts (1 in Wales). Scotland held 3 events, Ireland 2 events and Wales 1 event. Academic hosts include; primary and secondary schools, colleges and universities. Of the 49 held at academic venues information regarding the schools for 5 of the events could not be found and 5 events were held at places that had already hosted events. This information is summarised in the table below (Table 1).

Table 1: Summary of Events

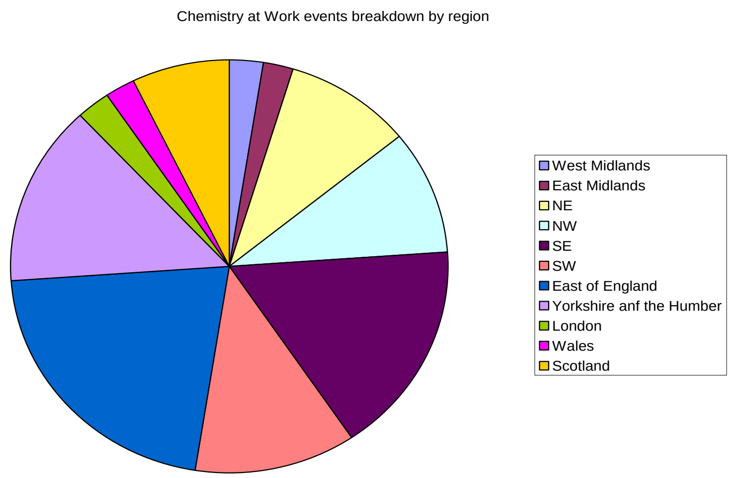
Total number of events 59							
			Host				
Academic	49			**Non Academic**	10		
England	**Ireland**	**Scotland**	**Wales**	**England**	**Ireland**	**Scotland**	**Wales**
43	2	3	1	9	0	0	1
No information	5						
Repeat Hosts	5						

In each trend section the exact number of events being referred to is stated and explained. Only information about academic hosts is included unless otherwise stated.

- Events breakdown according to region

Chart 1 shows the regional breakdown of the chemistry at work events. A total of 42 events are considered here; 49 academic events, 5 with no information, 2 from Ireland.

Chart 1: Chemistry at Work events breakdown by region



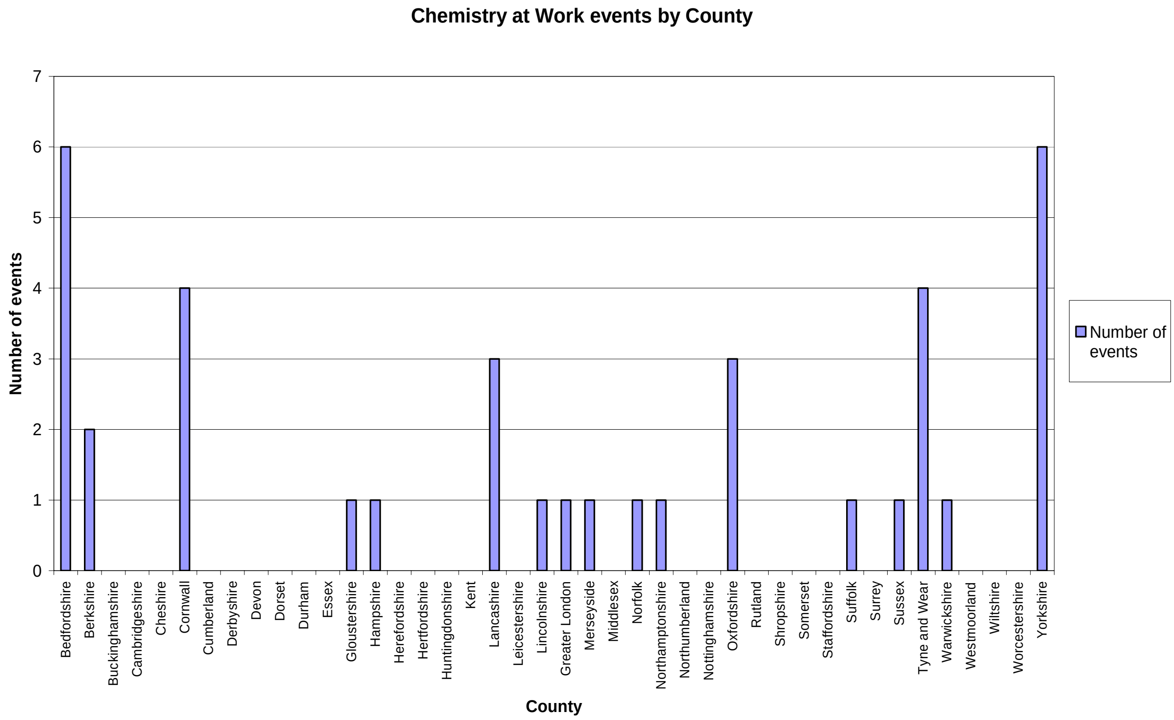
The regions that have the highest proportion of events are the East of England (9), the South East (7) and Yorkshire and the Humber (6). Those regions are however the ones that have academic hosts holding 2 or more events (high host performers are listed below).

- Events breakdown by county

There are 38 events being considered, from the 49 academic events – 5 have no information, 2 are from Ireland, 3 are from Scotland and 1 from Wales. This is shown in Chart 2. The highest performing counties are Bedfordshire (6 events), Yorkshire (6 events), Tyne and Wear (4 events) and Cornwall (4 events). Interestingly Cornwall and Tyne and

Wear both fall in regions that do not have the highest proportion of events held within them. Cornwall hosts 4 of the 5 events for the South West and Tyne and Wear hosts all 4 of the North East's events.

Chart 2: Chemistry at Work events by county



- Events breakdown by type of host

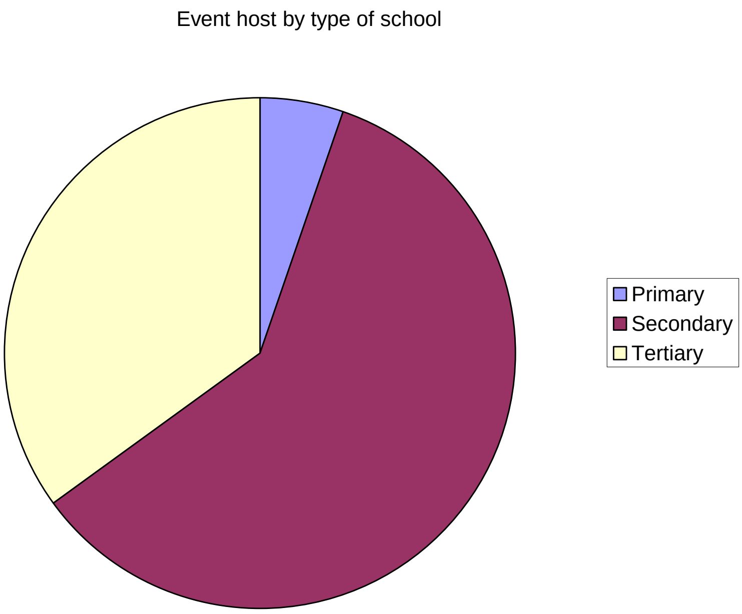
The data was broken down according to whether the host was academic or non-academic and the results presented below are just for the academic hosts. To be academic the host venue must be a primary or secondary school, a college or higher education institute. The events begin considered are; 49 academic hosts and 10 non academic hosts, however there are: 5 repeat hosts, 5 with no information and 2 academic hosts in Ireland giving a total of 47 hosts (Chart 3).

Over half of the academic hosts (59%) are secondary schools with primary schools contributing just (5%). Possible reasons for this disparity include:

- The majority of schools who are able to apply for science specialist status are secondary schools

- Primary school aged children may not be the most appropriate audience for the events presentations

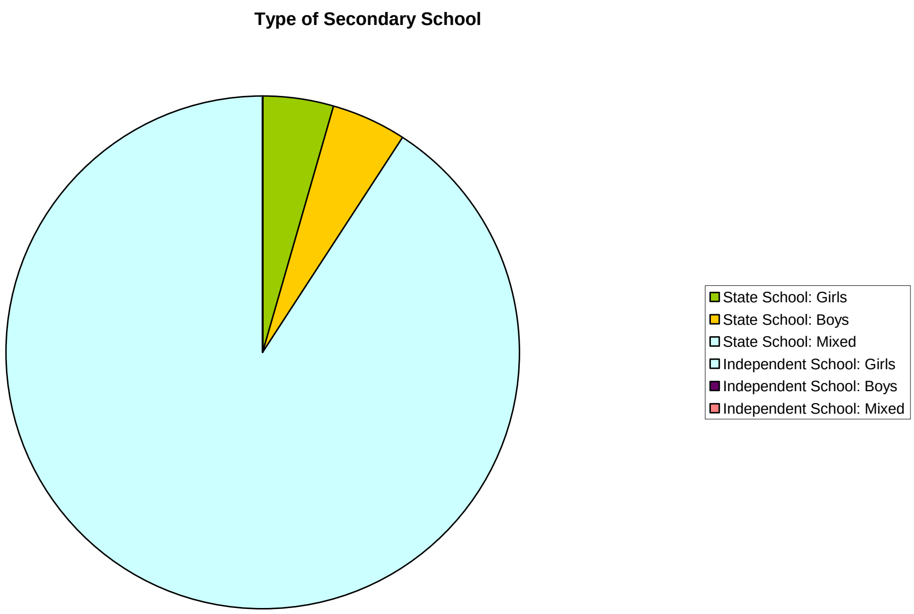
Chart 3: Chemistry at work events breakdown according to the type of academic host holding the event



- Secondary Schools

The secondary schools data (22 schools in total) was further analysed by considering the categories; state (mixed, girls and boys) and independent (mixed, girls and boys) and is shown in Chart 4.

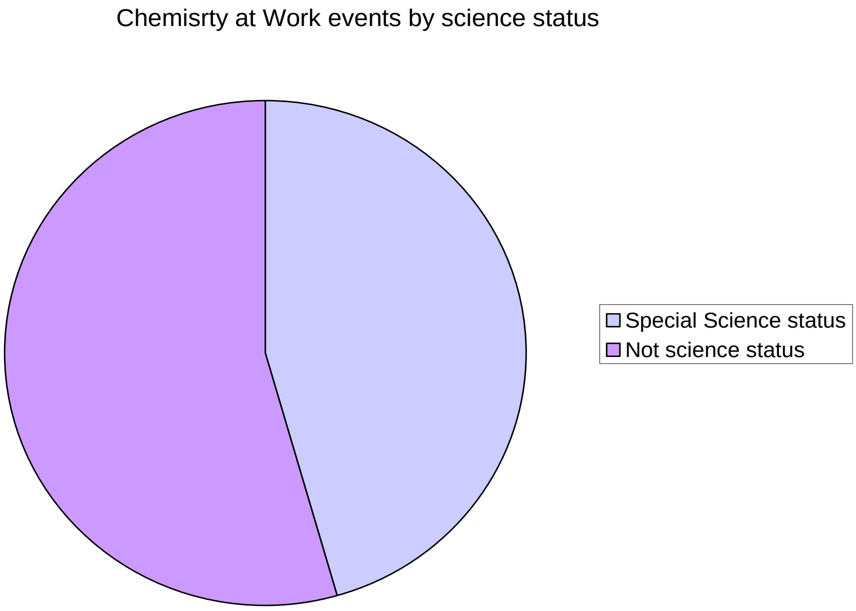
Chart 4: Chemistry at Work events according to the type of secondary school that hosts them



Interestingly all of the host schools are state schools, the majority of which were mixed. There was one all girls' school and one all boys', The all girls' school was Challney High School for Girls, and the all boys' school was Challney High School for Boys evidence suggests that the schools held the event in partnership.

Chart 5 illustrates the proportion of secondary schools that have science specialist status. This is a scheme within which Specialist Schools receive extra funding from the government to pursue developments in their chosen specialism and to work more closely with community partners.

Chart 5: Secondary schools who host Chemistry at Work events according to whether or not they have special science status.



The chart shows that the schools are split roughly in half with 45% of schools having specialist science status.

High performers

There are 4 places which have hosted multiple events according to region;

East of England

2 events held at Challney High School, Stoneygate Road, Luton, Bedfordshire, LU4 9TJ, 01582 599921

Yorkshire and the Humber

3 events held at University of York, Heslington, York, North Yorkshire, YO10 5DD, 01904 432460 – 1 in 2004 and 2 in 2007

South East

2 events held at Blessed Hugh Farringdon Catholic School, Fawley Road, Southcote, Berkshire, RG30 3EP, 0118 9574730

2 events held at Peers School, Sandy Lane West, Littlemore, Oxfordshire, OX4 6JY, 01865 774311

Chemistry: the next generation

This is a strand of the HEFCE funded by the RSC project 'Chemistry for our Future'. It has aims that overlap with the Chemistry at Work programme. It was piloted in the North West, London and the East Midlands in 2004 – 2006, and Yorkshire and Humber, the North East and South East in 2006. During 2004 – 2006 over 12,000 students were involved in hands on chemistry activities. 41% of them said they were more likely to consider chemistry or the chemical sciences as a degree subject and career choice after participating in the scheme.

STEM Access Grants

Science, Technology, Engineering and Mathematics Network (STEMNET) aims to ensure that more young people in the UK make a choice to enter science, technology, engineering and mathematics (STEM). STEM related careers at all levels are promoted by those who are undertaking them to the future generations and they are also made aware of the science and technology that surrounds them. STEM activities and experiences are bought in to the classroom and by linking those companies and other organisations that employ STEM educated people with schools allow the pupils to get clear ideas of the diverse careers available.

Funding for the project comes from the then Department for Trade and Industry (DTI) and the Department for Children, Schools and Families (DfES). The funding is used to allow STEMNET to work in collaboration with an extensive range of partner organisations including: government departments, industry professional institutions and local SETPOINTS. SETPOINTS are hosted by specially selected organisations skilled in facilitating links between education and the wider STEM community and working with other STEM partners. The SETPOINTS have responsibility for an assigned area which controls the number of schools and colleges that they work with.

STEMNET coordinates 53 SETPOINTS and together with the associated partner organisations work to provide schools with access to a wide range of programmes, resources and activities to help give a real world sense of how STEM subjects can lead to high-quality jobs. A programme similar to the Royal Society Role models scheme is also in operation, called the STEMNET's Science and Engineering Ambassadors. Within this people with STEM backgrounds, from over 1,000 different organisations offer time and expertise to help people in schools. In some cases undergraduate students are also ambassadors.

The STEM Access grants are part of the STEMNET project and will be focused on in this report. The Office of Science and Innovation within the DTI seeks to engage under represented groups in STEM. The grants provide an opportunity for schools to access funding to engage in STEM activities especially black and ethnic minority (BME) pupils which research has shown are under represented in STEM, especially those of Caribbean, Pakistani and Bangladeshi origin. Schools are able to bid for up to £10 000 per year to support meaningful STEM activities to engage their pupils and which:

- Involve a significant number of pupils of BME - at least 50%
- Support the work related learning agenda
- Utilise existing STEM schemes
- Demonstrate links to the world of work
- Involve STEM role models

The scheme has been running for two years now and a list on the website is given for the schools that obtained grants in 2006 - 2007 and those that have been successful for 2007 - 2008. This perhaps means that one of the gaps in the data is the grants that were awarded in 2005 - 2006. A further gap is that the value of the grant that was awarded is not listed on the website.

A further initiative is a STEM Enterprise Project for Schools, which was started in 2006 by: the East of England Development Agency, STEMNET and the 6 Eastern Region SETPOINTS. The project hoped to address the declining take-up of science and technology related subjects and consequent challenges in recruiting young people and therefore the slow start-up rate for new business enterprise in the region. For example one project was supported by SETPOINT Suffolk and Mid-Anglia Enterprise agency with funding from the East of England Development Agency, called "Making and marketing moving toys".

There are 47 schools listed on the website (those for 2006 - 2007 and 2007 - 2008 have been included in the analysis) which will be analysed to identify key trends, however one of them is in Wales and is omitted from some sections.

Regional Breakdown

The largest number of grants was allocated to London followed by the North West, Charts 1 and 2 illustrate this by actual numbers then by percent.

Chart 1: The number of STEM Access grants obtained expressed by region (total number of grants = 47)

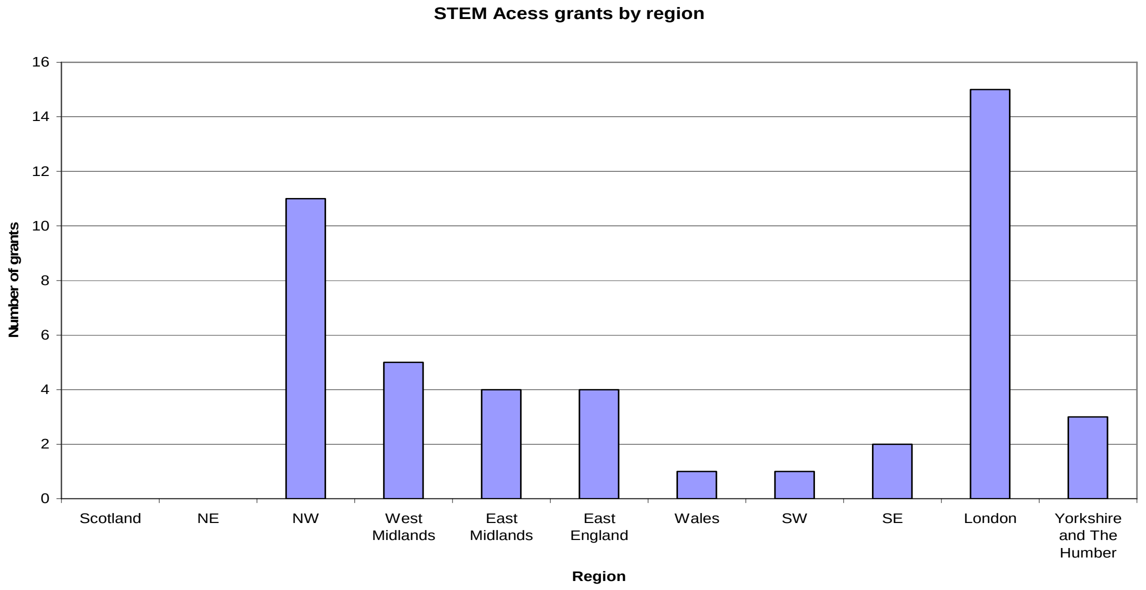
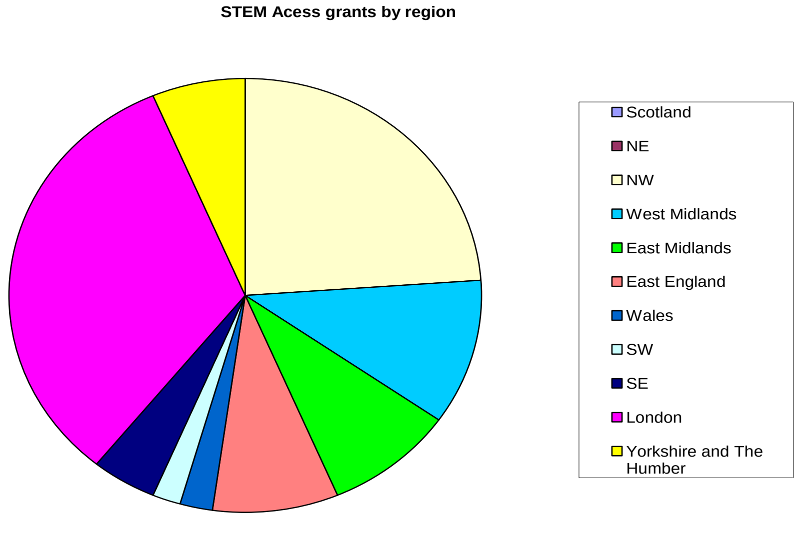


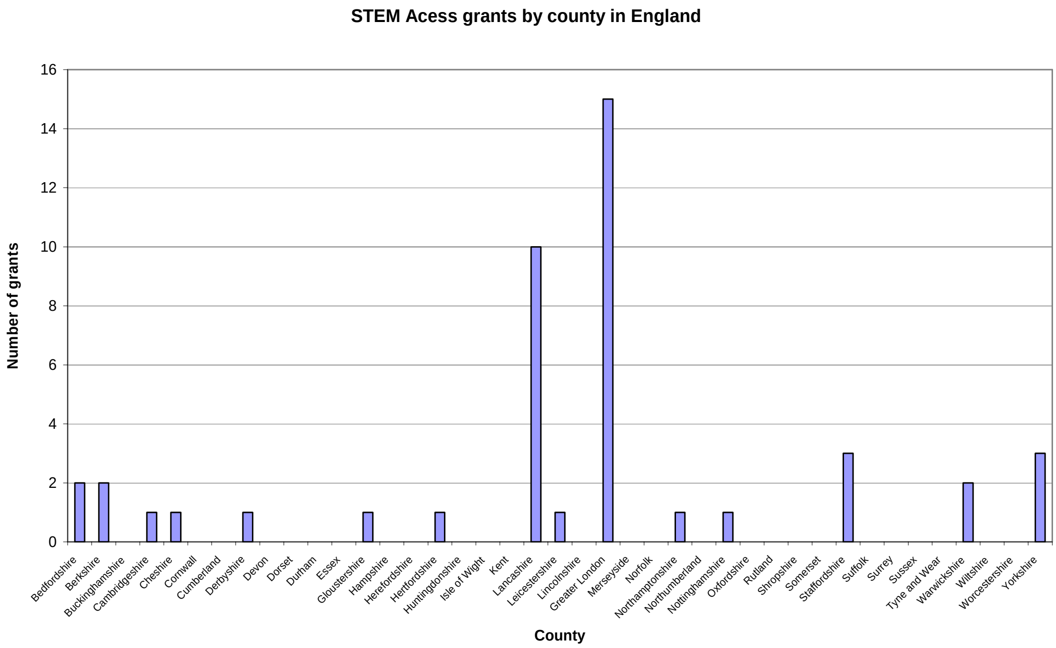
Chart 2: The number of STEM grants obtained in each region expressed as a percentage of the total



County Breakdown

The highest number of grants goes to London with 15 followed by Lancashire with 10, which reiterates the regional breakdown (Chart 3).

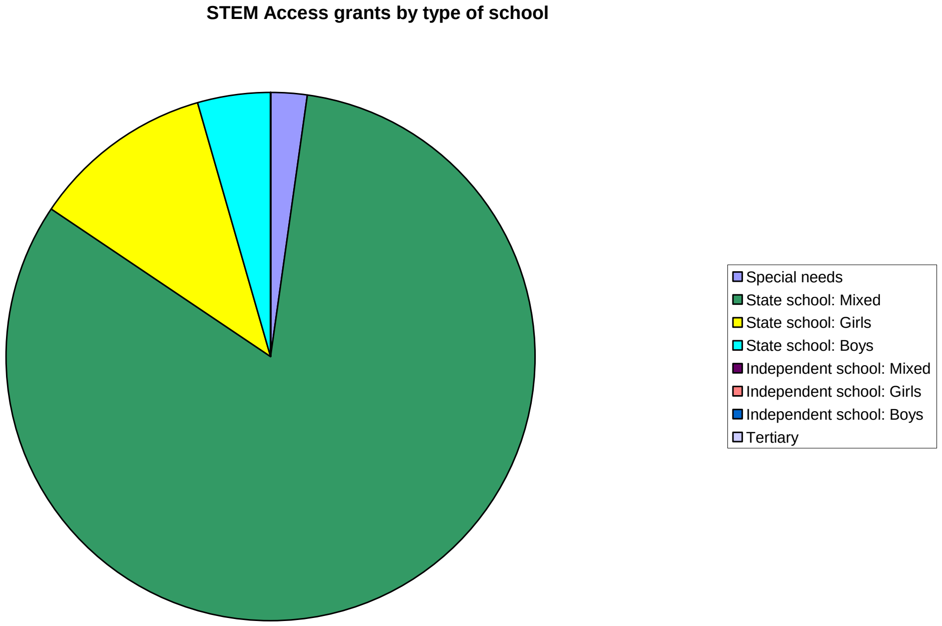
Chart 3: Breakdown of STEM Access grants by region



Type of School

It is apparent from Chart 4 there are no STEM Access grants awarded to independent schools or tertiary education organisations. For the state school data more girls' schools were awarded grants than boys' schools (5 and 3 grants awarded respectively).

Chart 4: Breakdown of STEM Access grants by the type of school that receives them



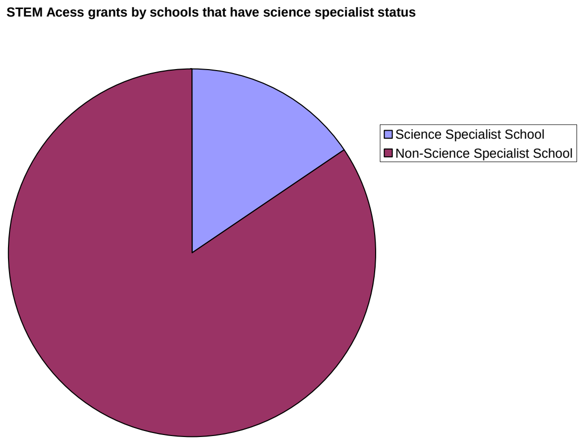
High Performers

There are no schools listed which have been awarded two or more STEM Access grants, however, this may be explained by the short time the programme has been running.

Science Specialist Status

Approximately 15% of the schools who receive the grants have science specialist status (Chart 5).

Chart 5: STEM Access grants allocated to schools with science specialist status



Case Studies

The website gives a brief outline of the projects that have taken place. In the majority of cases the projects are set to run for a number of years, most frequently 3 years. It could be that the schools are unable to apply for any more grants while they have a grant running - and if this is the case they are "high performers" in their own right.

Rolls-Royce Science Prize

Background Information

Rolls-Royce is an aerospace, marine and energy company that supplies power systems and services to companies such as, airlines, armed forces, navies and other marine customers.

Rolls-Royce invests in education to:

- Raise standards in education
- Support future resource needs
- Promote engineering, science, technology, business and enterprise
- Influence policy and strategy in education
- Develop employees
- Raise the profile of Rolls-Royce

The Prize

The Rolls-Royce Science Prize was launched in 2004, and is a two stage competition open to teams of 2-6 adults, designed to promote teamwork within education institutions. The team members may be teachers or related school staff (heads of departments, teaching assistants, laboratory technicians etc.). The total prize fund is £120,000, the final winner receiving £15,000 for science education in their school or college.

The first stage of the competition sees teams submit a science teaching project idea that is relevant to their institution. The proposal must contain: a detailed budget, teaching objectives, implementation guides, and an outline of the monitoring and evaluation strategy. Entries are submitted into one of three age categories;

3 – 11 years

11 – 16 years

16 – 19 years

From all the entries, nine finalists are chosen to go on to stage two, and 50 schools and colleges of high standard are chosen to receive the Special Merit Award of £1,000.

The nine finalists each receive an award of £5,000, a video camera and the help of a specially allocated mentor, to implement and complete their project. The finalists have 24 weeks to complete their program and submit a video diary of the progress, before the final judging. The eventual winner receives £15,000 and a day out with the Red Arrows, the runner-up receives £10,000.

Case Study of 2006-2007 Winner

The 2006-2007 winner of the Rolls-Royce Science Prize was St Stephen and All Martyrs' C of E Primary School, Bolton.

"Our commitment to our pupils is to help them develop both academically and excite their imagination by engaging them in the richness of learning - not just things, but learning in different ways and learning for life."

The winning project proposed to take an area of land behind the school which was once a refuse site and is currently wild and overgrown, to turn it into a place of adventure and scientific learning.

The science project aimed to give pupils a genuine experience of scientific discovery. Based on Darwin's expeditions, the pupils would carry out their own expedition including camping out in the 'uncharted territory' behind the school, where they would identify, classify and illustrate wildlife and fauna. This would allow children to explore science in a very practical way and ensure motivation by having real experiences of the things they learn.

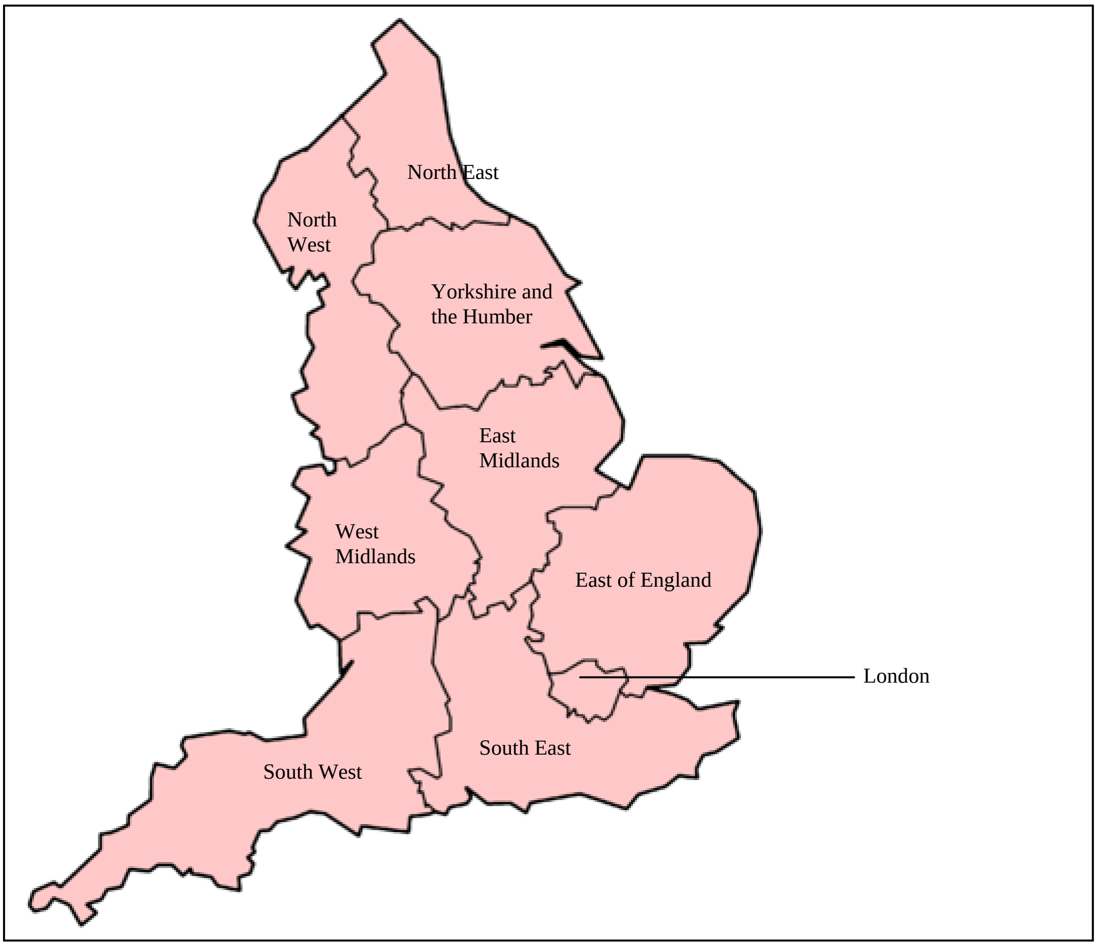
Identification of key trends in previous participating schools and colleges (competitors)

The Rolls-Royce Science Prize website lists all previous winners (but not all entrants) to the competition. This data was analysed, by region, county and school type to identify some key trends of all the finalists, special merit award winners and overall winners.

By Region and County

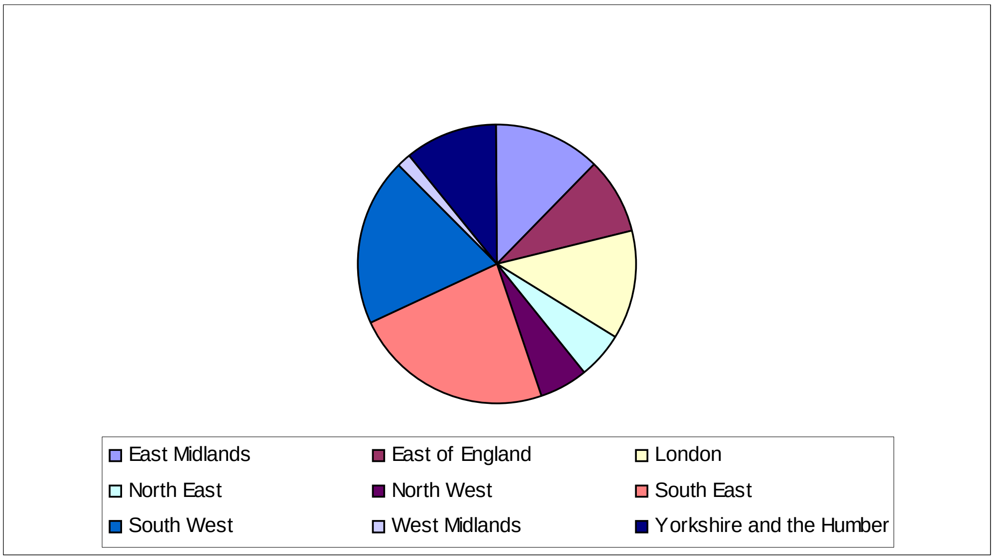
The results show that most previous winners are from schools and colleges in England, with a total of 56; Scotland, 4; Wales, 4 and Ireland, 4. Following on from this the 9 individual regions of England will be examined. The government office regions of England are shown in Figure 1.

Figure 1: Map Showing Government Office Regions of England



The results (Chart 1) show that the South East has the greatest number of winners (13) and the West Midlands has the least (1).

Chart 1: Numbers of previous winners of the Rolls Royce Science Prize by Region



This is interesting because the West Midlands have a large population size (Table 1) and historically the region has had a focus on science and industry.

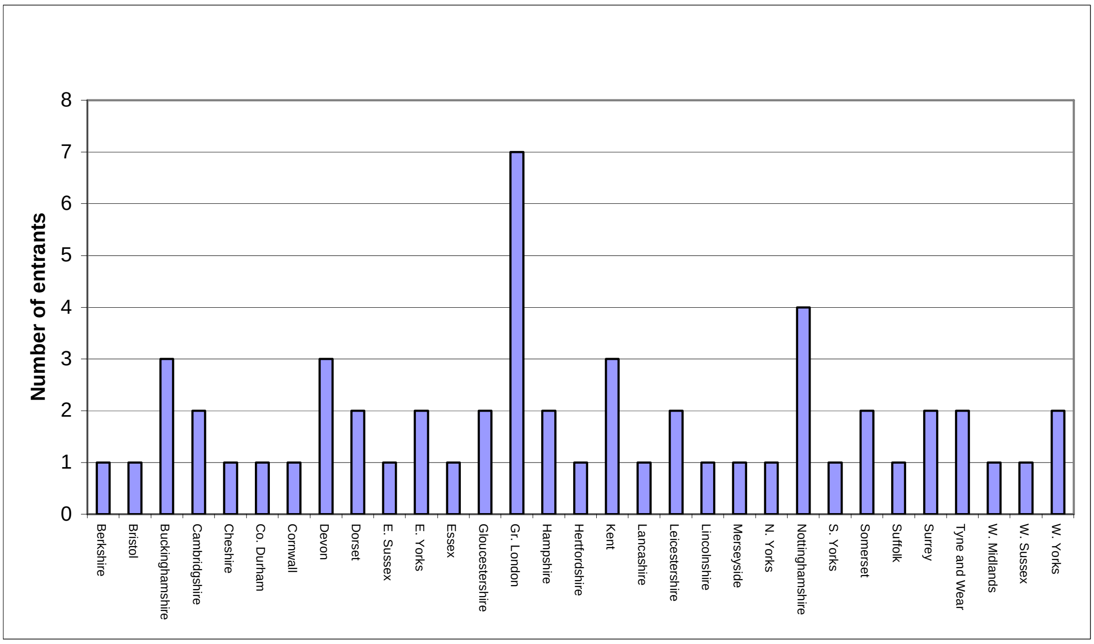
However without data to allow comparison of winners to the total number of entrants this data is only speculative.

Table 1: Regional data (ranks are shown in parenthesis)

Region	Population (2001 Census)	Area (sq. miles)
North East	2515479 (9)	3317 (8)
North West	6729800 (3)	5469 (6)
Yorkshire and Humber	4964838 (6)	5953 (5)
East Midlands	4172179 (8)	6033 (4)
West Midlands	5267337 (5)	5020 (7)
East England	5388154 (4)	7382 (2)
London	7172036 (2)	609 (9)
South East	8000550 (1)	7373 (3)
South West	4928458 (7)	9200 (1)

When the data is further examined by county (Chart 3) it shows, perhaps not surprisingly, that London has the greatest number of finalists (7). The mean number of winners per county was 1.2, however it must be noted that 17 out of the total 48 English counties were not represented at all.

Chart 3: Number of Previous Finalists by County

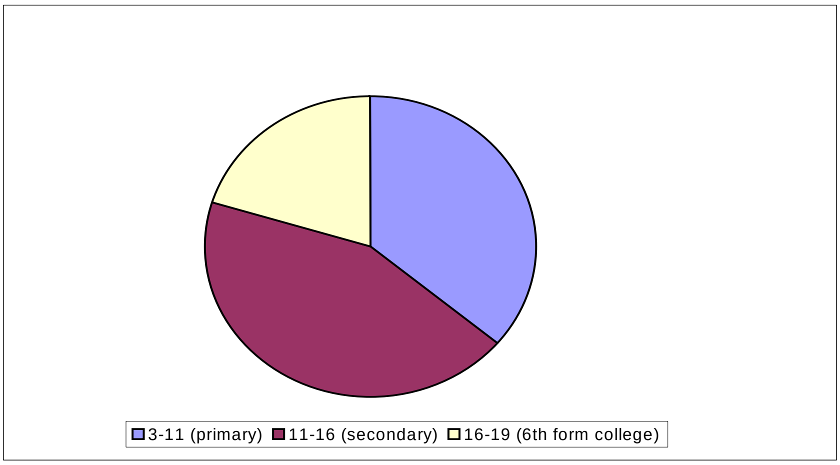


By School Type

The types of schools to enter the Rolls-Royce Science Prize can be broken down into three groups; primary, secondary and 6th form colleges, based upon the age group category for entry into the Science Prize.

The results are shown in Chart 4, below. Here it can be seen that the schools teaching 11-16 year olds (secondary schools) makes up the largest group (44.5%). It should also be noted that many of these schools have a 6th form, however no cases could be found where a school entered the competition in both the 11-16 and 16-19 age categories.

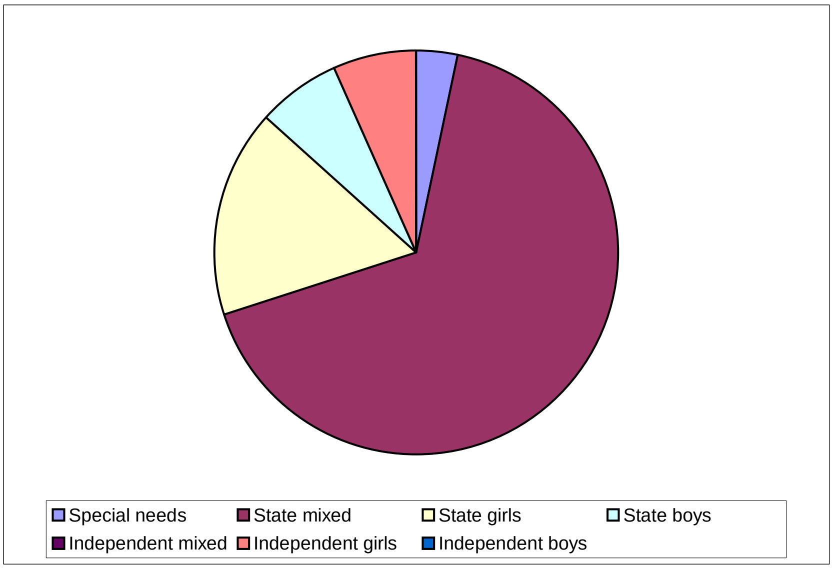
Chart 4: Number of finalists by age group (school type; primary, secondary college)



To further study the secondary school finalists, the following categories were considered; state (mixed, girls and boys), independent (mixed, girls and boys) and special needs schools.

The majority of the finalist schools are co-educational state schools (67%), (Chart 5).

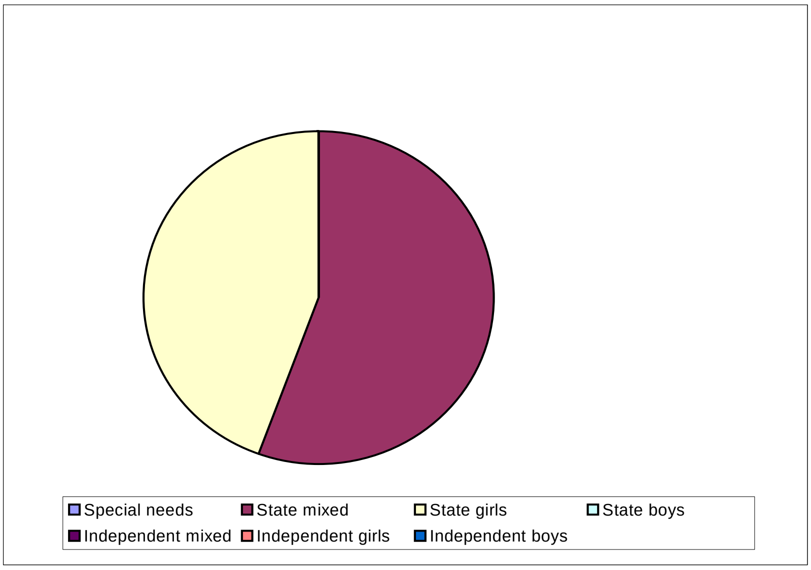
Chart 5: Number of Finalists by Secondary School Type



Of the schools in the competition, some have been awarded specialist school status. Specialist schools are part of the UK Government plan to raise education standards in secondary schools. The Specialist Schools Programme (SSP) provides schools with funding, in collaboration with private sector sponsors, to allow schools to focus on their chosen specialism. There are ten specialisms (arts, business & enterprise, engineering, humanities, languages, mathematics & computing, music, science, sports and technology) and these can also be combined e.g. science and engineering.

Therefore the data can also be analysed by looking at science status. Of the 30 secondary schools, 9 have been awarded specialist science or engineering status. Chart 6 illustrates the proportion of each type of secondary school to have science specialist status.

Chart 6: Number of finalists to have been awarded specialist status



High Performers

A number of schools can be identified as high achievers in that they have been a finalist on more than one occasion. The available data on these particular schools has been compiled into Table 2, below.

Table 2: Details of schools who have had more than one win

School	Region	Age Group	Number of wins	Additional information
Ashdown Technology College, Dorset	South West	11-16	2	
Broadlands Comprehensive School, Bristol	South West	11-16	2	
Dr Challoner's Grammar School, Buckinghamshire	South East	11-16	2	Boys only
Fulston Manor School, Kent	South East	11-16	2	
Ivybridge Community College, Devon	South West	11-16	2	Leading edge initiative
Loreto College, Coleraine	Ireland	11-16	2	
Marling School, Gloucestershire	South West	11-16	2	Boys only, engineering college
Richard Huish College, Somerset	South West	16-19	3	
Seevic College, Essex	East of England	16-19	2	
St. Olave's Grammar School, Kent	South East	16-19	4	Boys only, co-ed 6th form
Ysgol San Sior, Llandudno	Wales	3-11	2	Eco school

Gaps in the Information

A large proportion of this data can only be analysed in a generalised way as the information on applicants is not available. The major areas of lacking data are:

1. No information on how many entrants in total. The science prize results in 59 entries being awarded a prize of some description, but entries can also be awarded a certificate of entry. However there is no discrimination of these categories on the website, or lists of schools which have entered and failed to receive any award.

2. The Rolls-Royce website provides a search engine of all previous winners, however this search engine has severe limitations, in that only the first 50 results can be accessed, this means without having very specific search terms the total data can never be accumulated.

The British Science Council

http://www.britishcouncil.org/science

The **British Council Science Programme** supports scientific collaboration through the exchange of ideas and knowledge. It aims to build lasting relationships and networks between young scientists around the world, make connections between science, technology and society, and to stimulate debate about the impacts on science on people's lives. The British Council Science in the UK has developed two programmes specifically for young people, The Eden Project for School and Colleges and the F1 Team in Schools Challenge.

The Eden Project for School and Colleges

http://www.edenproject.com/education

The **Eden Project** aims to promote the understanding and responsible management of the vital relationship between plants, people and resources leading to a sustainable future for all. The Eden Project for Schools and Colleges offer an imaginative, experiential education programme that aim to breathe excitement and discovery into learning amongst young people. In September 2005, the Eden project established its own Education Centre, the Core, which provides a permanent home from which to run their own specific programmes. The Eden Project has developed several programmes and for pupil and teachers. It has its own designated website and a regular newsletter. The project does not prove a list of the participating schools.

The Formula One Team in Schools Challenges

http://www.fiinschool.co.uk

The **F1 Team in Schools Challenge** is a competition, open to all UK based secondary schools and colleges, to design and manufacture CO_2 powered model racing cars (dragsters). The project is designed to inspire a new generation of engineers, promoting science education.

The challenge aims 'to help change perceptions of engineering, science and technology by creating a fun and exciting learning environment for young people to develop an informed view about careers in Engineering, Science and Technology'

F1 in Schools founding partners Denford, BAE SYSTEMS and Jaguar are working together to produce an exciting educational experience for students and teachers alike, challenging negative stereotypes associated with engineering in a fun and positive way.

F1 in Schools is a not-for-profit company with the aim of raising the profile of engineering as a career through the CAD/CAM Design Challenge. The Challenge has a wide base of support and major UK sponsors include The IET, Denford, Jaguar Cars, The Learning Grid, City University London, Make your Mark, The Royal Academy of Engineering and the Year in Industry.

THE CHALLENGE

Students are given a brief to design a model CO_2 powered F1 Car of the future using a CAD (Computer Aided Design) package such as Solid Edge. Once the cars are designed, they are transferred into CNC (Computer Numerical Control) language using a CAM (Computer Aided Manufacture) package such as EdgeCAM. Cars are then manufactured on a CNC machine such as the Denford MicroRouter. Students are required to test their designs before attending a regional final, either in school or at their local manufacturing/test/race centre.

If schools don't have the equipment to make their final model themselves, they can link up to a manufacturing centre through video conferencing and see their model being made. There are various 'Manufacturing Centres' throughout the country. Teams must also produce supporting evidence of their design in a folder including an orthographic projection of the car and a colour isometric drawing or 3D rendering of the teams final idea.

The teams compete regionally to win a place at the national final. Overall winners of the championship season go on to represent the UK and compete at the F1 in Schools World Championships.

The Challenge has its own dedicated website. A list of also of School finalists and winners, by region and year is available. The website also publicises success stories and case studies of teachers, students, supporters and partners involved in the challenge to encourage greater participation in the Programme.