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AUDITOR GENERAL

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Department for Education

Educating the next generation of scientists

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Department for Education

Educating the next generation of scientists

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Amyas Morse
Comptroller and Auditor General

National Audit Office

5 November 2010

A strong supply of people with science, technology, engineering and maths skills is important to promote innovation, exploit new technologies, produce world-class scientists and for the UK to compete internationally.

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Contents

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This report can be found on the National Audit Office website at www.nao.org.uk/young-scientists-2010

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Summary

1 A strong supply of people with science, technology, engineering and maths skills is important to promote innovation, exploit new technologies, produce world-class scientists and for the UK to compete internationally.

2 In 2002, a government-commissioned review identified concerns about the future supply of such skills to the UK economy. Two years later, the ten-year *Science and Innovation Investment Framework* set out a strategy to improve the UK's standing as a centre of research, increase investment in research and development, and support a strong supply of scientists, engineers and technologists. A key aim was to increase the skills of young people coming through the school system by improving the quality and quantity of science teachers, improving results for pupils studying maths and science, and increasing the numbers taking related subjects in post-16 and higher education.

3 This report evaluates progress by the Department for Education[1] in increasing take-up and achievement in maths and science up to age 18, and the extent to which specific programmes to raise the quality of school science facilities, recruit and retain science and maths teachers, and improve the appeal of science to young people have contributed to any increase.

4 A summary of our methodology can be found in the Appendix.

Main findings

Trends in take-up and achievement

5 GCSE science entries have been stable over the last five years at around 1.1 million per year. There has been an increase in pupils taking A-level chemistry and maths over the same period, though physics has increased more slowly. Numbers of pupils achieving A-C in A-level biology, chemistry, physics and maths have also increased.

Critical success factors in improving take-up and achievement

6 Our literature review and survey of 1,274 children and young people suggest that the following are critical success factors in improving take-up and achievement in science and maths:

- careers information and guidance
- quality and quantity of school science facilities
- quality and quantity of science teachers
- image and interest
- availability of separate GCSE sciences ('Triple Science')

Careers information and guidance

7 The Department acknowledges that careers information and guidance in schools has been patchy. Only 18 per cent of young people we surveyed were satisfied with the careers advice they had received relevant to science, technology, engineering and maths. The Department launched a new strategy on information, advice and guidance in October 2009, and until March 2011 is running a career awareness pilot in 30 schools to establish a more coherent structure for young people to learn about careers relevant to science and maths.

Quality and quantity of school science facilities

8 The Department has not collected routine data to measure progress against a target set in 2004 to bring all school laboratories up to a satisfactory standard by 2005-06, and to a good or excellent standard by 2010. A 2005 research report suggested that science accommodation remained either unsafe or unsatisfactory in around a quarter of secondary schools, while a 2006 follow-up study estimated that, at the rate of progress at the time, the 2010 target would not be met until at least 2021.

9 Schools with a specialism in science, technology, engineering or maths and computing are effective in bringing together the programmes and resources that support good take-up and achievement in science and maths. The availability of schools with these specialisms varies widely between local authorities, with higher numbers in areas of lower deprivation.

Quality and quantity of science teachers

10 Teaching is of better quality where teachers hold qualifications in the subjects they teach. The Department has sought to increase teaching by specialists in maths, chemistry and physics. It anticipates that targets set by the previous Government for numbers of specialist chemistry teachers will be met, but that those for physics and maths will not.

11 The 'Transition to Teaching' programme aims to promote a teaching career to people in other professions with relevant degrees who are considering a career change. Although take-up has been limited to date, the economic climate presents an opportunity to recruit skilled employees who may be facing redundancy from industry into teaching.

12 Science Learning Centres are a network of ten facilities across England providing specialist continuing professional development to science teachers. There is evidence that participation by teachers in Learning Centre programmes is associated with improved teaching and learning, and higher take-up and achievement in science at their schools, but take-up by teachers varies between areas.

Image and interest

13 The UK generally compares favourably in international comparisons of young people's attitudes towards science and maths, particularly in the value they place on maths, their confidence learning maths, and the extent to which they recognise the usefulness of science. However, in recent years the UK has lost ground in areas such as enjoyment, interest, and motivation to pursue science and maths further.

Availability of GCSE Triple Science

14 Pupils studying 'Triple Science' (separate biology, chemistry and physics) are more likely than those studying combined science to continue science study at A-level and to achieve higher grades having done so. While starting from a low base, pupil take-up of the individual sciences has increased by almost 150 per cent in the last five years. The number of secondary schools offering Triple Science has increased rapidly, although by June 2009 just under half still did not do so.

15 Recent research shows that, compared with other pupils, pupils from more deprived backgrounds achieve relatively larger improvements in their future A-level science and maths outcomes when offered Triple Science at GCSE than when offered only combined science. However, Triple Science is less widely available in areas of higher deprivation, where it could potentially have the greatest impact on take-up and achievement.

Effectiveness of programmes to increase take-up and achievement in maths and science

16 In 2004 there were over 470 initiatives aimed at improving take-up and achievement in school science and maths, run by a wide range of organisations. Some two thirds had no evaluation or none was planned. From 2006, a national programme has had the aim of rationalizing programmes for schools that receive national funding and endorsement.

17 We examined a number of the larger recent programmes, covering around £35 million of expenditure per year, and found that they were widely available to schools and take-up was high, although a small number of schools did not access any. There are considerable regional variations, indicating that further targeted incentives to manage take-up are required.

18 Schools using the programmes have a greater proportion of pupils studying these subjects, and several programmes are associated with increases in take-up and achievement of separate sciences at GCSE, and maths and science at A-level. However, it is difficult to establish whether this is a direct consequence of participating in the programmes, or whether schools with an existing focus on science tend to access more such programmes as a result.

19 Up to a point, take-up and achievement in GCSE sciences is proportionally associated with the number of different programmes in which schools participate. However, there may be diminishing returns when schools access larger numbers of interventions with similar objectives. More generally, our analysis suggests that participation in these programmes has less influence on take-up and achievement than other factors, such as pupil intake.

Value for money conclusion

20 The Department has focused resources on the appropriate critical success factors to improve take-up and achievement in school science and maths, and has made good progress in areas such as A-level maths and availability of GCSE Triple Science. It has been less successful in aspects such as teacher recruitment and take-up of A-level physics.

21 Increased take-up and achievement in school science and maths is, as this report shows, dependent on a number of key factors. These need to be brought together in coherent pathways to maximise successful results and efficient use of public resources in pursuit of this objective. The Department has made progress in doing so, for example by rationalizing the previous plethora of initiatives within a national programme. However, gaps and inconsistencies in availability and uptake remain, creating a shortfall in value for money which the Department could and should address in developing its future programme for science and maths in schools.

Recommendations

22 In taking forward the policy priorities of the new Government, the Department should develop an overarching programme with a clear logic, based on evidence of cause and effect. The programme should provide a framework with clear priorities, a well-defined critical path and appropriate measures of progress. It should provide a basis for engaging with local authorities, schools and colleges on the actions required in the following key areas:

- a systematic approach which gives assurance that there will be sufficient teachers with a specialism in maths, chemistry or physics;
- more even take-up of continuous professional development opportunities for teachers, particularly in local authority areas where fewer schools are currently using Science Learning Centres;
- a realistic assessment of what progress can be made to bring school laboratories up to a good or excellent standard, since the previous target was neither informed by robust data nor achieved within the specified timeframe;
- actions at local level to give all young people access to:
  - a curriculum that includes the study of separate sciences; and
  - a school or college that performs well in science and maths, whether through a relevant specialism or by other effective means;
- further development of the analysis presented in this report with a view to:
  - evaluating more coherently and consistently the efficacy and cost-effectiveness of individual programmes in increasing take-up and achievement; and
  - providing information on local use of programmes to support reviews of whether take-up is sufficient and appropriate.

Part One

Introduction

1.1 A wide range of government activity in recent years has related to maintaining and developing the supply of scientists, including primary and secondary school science teaching, further and higher education, scientific research and developing job opportunities through regional economic development. In addition to the considerable sums spent on teaching science, technology, engineering and maths (for example around £2.3 billion a year on teaching maths in primary schools alone[2]), we estimate that in recent years around £100 million has been spent annually on related programmes: around £47 million by the Department for Education, £13 million by the Department for Business, Innovation and Skills, and £34 million by the Higher Education Funding Council for England. Activities aimed at children and young people up to the age of 18 account for approximately £40 million of this expenditure.

The policy background

1.2 A review of the supply of science, technology, engineering and maths skills to the UK economy,[3] published in April 2002, identified the following concerns about the supply of skills from schools and further education:

- declining numbers of people studying maths, engineering and the physical sciences;
- inability of such courses to inspire and interest pupils, particularly girls;
- problems with recruitment and retention of teachers in science, technology, engineering and maths;
- poor environments in which practical lessons were taught; and
- inadequate careers advice in schools, affecting pupils' desire to study science, technology, engineering and maths at higher levels.

1.3 Following the review, the then Government produced a ten-year *Science and Innovation Investment Framework*,[4] setting out its strategy to improve the UK's standing as a centre of research, increase investment in research and development, and support a strong supply of scientists, engineers and technologists. A key aim was to increase the skills of young people coming through the school system by improving the quality and quantity of science teachers and lecturers, improving results for pupils studying maths and science, and increasing the numbers choosing science, technology, maths and engineering in post-16 and higher education.

1.4 Following the general election in May 2010, the current Government has yet to announce its detailed funding, policies, programmes and targets for improving teaching, participation and achievement in maths and science once the current funding term expires in March 2011. However, the lessons derived from the programmes analysed in this report will be relevant to developing new policies in this area.

Scope of the study

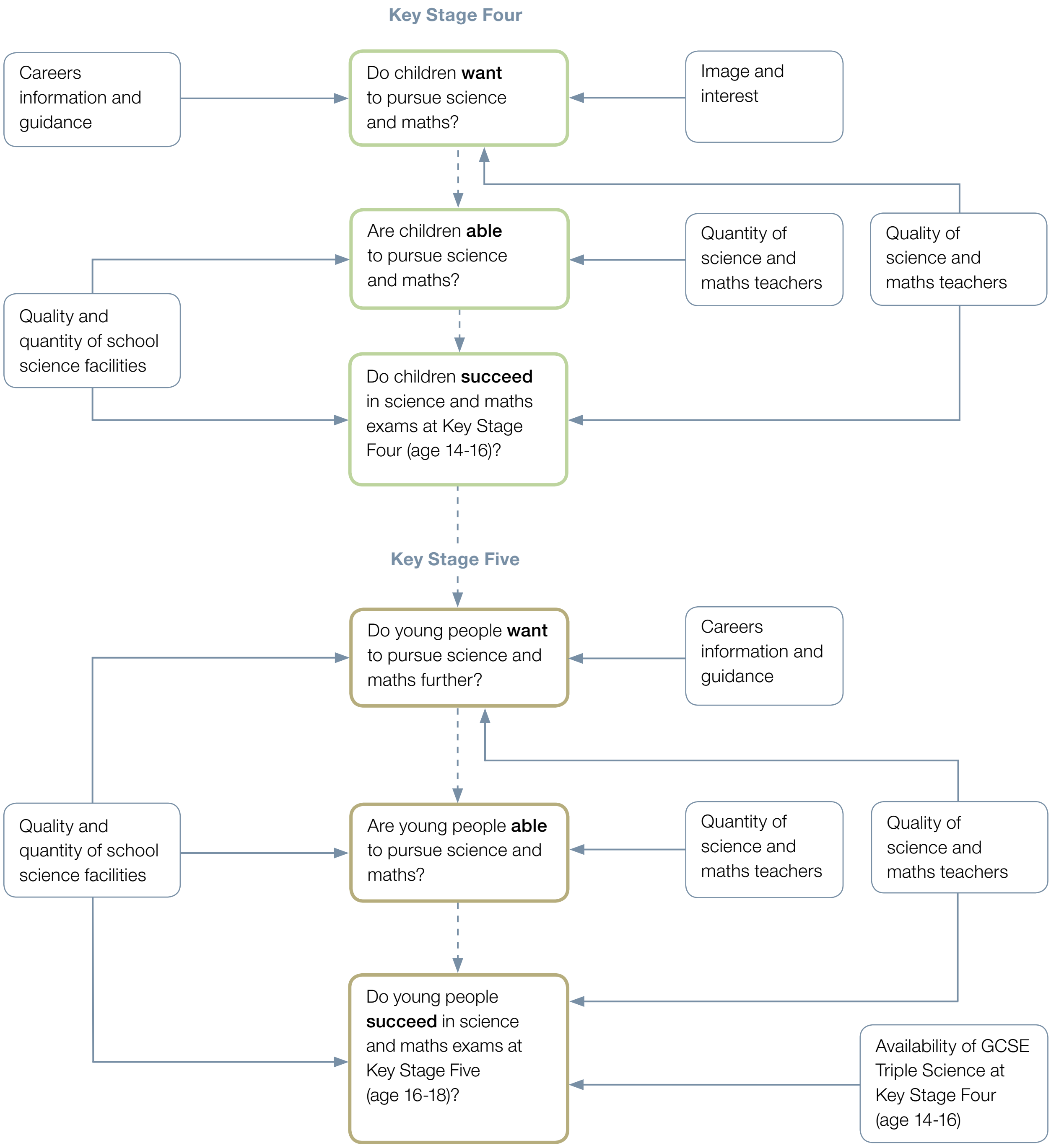
1.5 Recent research suggests that many pupils who could potentially follow a science-related career have already rejected this option by the age of 16.[5] Because of the importance of experiences in school and further education in shaping pupils' future plans, this report focuses on policies relevant to children and young people up to the age of 18. We evaluate trends in take-up and achievement in science and maths, and assess the effectiveness of major programmes in supporting progress. In particular, we focus on the following critical success factors, which our work identified as key to improving take-up and achievement in science and maths (**Figure 1**):

- careers information and guidance
- quality and quantity of school science facilities
- quality and quantity of science teachers
- image and interest
- availability of separate GCSE sciences ('Triple Science')

1.6 Following the *Science and Innovation Investment Framework* in 2004, the then Government developed a number of policies, structures and targets aimed at improving the supply of science, technology, engineering and maths skills to the UK economy. Details of those most relevant to children and young people up to age 18, along with their aims in respect of critical success factors and outcomes, are shown in **Figure 2** on page 12.

Figure 1

Critical success factors in improving take-up and achievement by young people in science and maths



Source: National Audit Office literature review and survey of 1,274 children and young people

Figure 2

Recent policy aims regarding critical success factors and outcomes for young people studying science and maths

	2004: *Science & innovation investment framework 2004-2014*	**2006:** *Science & innovation investment framework 2004-2014: Next steps*	**2006:** *The Science, Technology, Engineering and Mathematics (STEM) Programme Report*	**2007:** Public Service Agreement (PSA) 10 (2008-2011): *Educational Achievement*	**2007:** *The Children's Plan: Building Brighter Futures*	**2008:** *The STEM Framework*	**2009:** *Your child, your schools, our future: Building a 21st century schools system*
Critical Success Factors							
Careers information and guidance	Improve careers education and guidance; ensure quality information, advice and learning opportunities are available to help young people decide how to build on their science education through training, education or in employment	Improve awareness of the (science, technology, engineering and maths) career opportunities available				Improve the quality of advice and guidance for students (and their teachers and parents) about science, technology, engineering and maths careers to inform subject choice	Give all secondary school pupils access to high-quality careers education and information, advice and guidance
Quality of school science facilities	Bring school labs up to a satisfactory standard by 2005-06, and to a good or excellent standard by 2010	Improve the state of school science accommodation by making school science labs a priority					
Quality and quantity of science and maths teachers	Improve quality of science teaching by expanding CPD opportunities available to science teachers, and enhancing support for the new Science Learning Centres		By February 2007 explore and agree the role Regional Science Learning Centres could play, with other partners, in coordinating CPD for school staff and strategic planning		Establish a Transition to Teaching programme to attract more people with science, technology and engineering backgrounds into teaching	Improve the recruitment of teachers and lecturers in shortage subjects Improve teaching and learning through CPD for maths and science teachers	
Image and interest	Improve young people's experience of school science by enhancing learning and raising standards, to ensure that young people have sufficient knowledge and enthusiasm to pursue further science study post-16	Significantly expand the Science and Engineering Ambassadors scheme to support teachers and engage and enthuse pupils From 2006, pilot 250 after-school science clubs	By July 2007, agree no more than ten national schemes to receive national funding and endorsement; agree how to rationalise existing schemes and funding By February 2007 agree arrangements to improve coordination of curriculum enhancement and enrichment			Improve the quality of practical work in science Enhance and enrich the science, technology, engineering and maths curriculum	
Availability of GCSE Triple Science		By September 2008, all pupils achieving at least level 6 at KS3 to be entitled to study Triple Science GCSE, and all specialist science schools to offer it at least to all pupils achieving level 6+ at the end of KS3 Encourage all schools to make Triple Science available to all pupils who could benefit				Widen access to formal science and maths curriculum for all students, including access to Triple Science GCSE	By September 2014, give every student who would benefit from a more stretching science curriculum the opportunity to study Triple Science GCSE
Outcomes							
Take-up of science and maths		Achieve year-on-year increases in A-level entries in physics, chemistry and maths so that by 2014 entries are: physics: 35,000, chemistry: 37,000, maths: 56,000					
Achievement in science and maths	Improve success rates in science, technology and engineering for those in post-16 education	Continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs		Increase the proportion of pupils achieving 5 A*-C GCSEs including English and maths at KS4 to 53 per cent by 2011			

Source: National Audit Office review of government policy documents, 2004-2009

NOTE In February 2009 the then Government announced an additional target that by 2014, 100,000 maintained school pupils would enter Triple Science at Key Stage 4.

Part Two

Trends in take-up and achievement in school science and maths

2.1 A key priority in the ten-year strategy was to improve take-up and achievement in science and maths in schools. This part of the report examines recent trends in the numbers of children and young people studying these subjects, as well as the proportions achieving grades A*-C at GCSE and A-C at A-level.[6]

Take-up and achievement at Key Stage 4 (14-16 years)

Take-up

2.2 In 2006, a new GCSE science curriculum was introduced in place of 'Double Science', where pupils had received two identical grades for a course with double the regular coursework. Pupils may now take the renamed Core Science, plus one of two new complementary courses: the academic-focused Additional Science, or Additional Applied Science, which is vocationally focused. Pupils receive two individual grades. Most pupils follow this route, but a growing minority study for examinations in separate sciences, primarily biology, chemistry and physics.

2.3 **Figure 3** lists the main science subjects available at GCSE, with the total number of entries each year between 2001-02 and 2009-10. Adjusting the figures to acknowledge year-on-year changes in the number of young people aged 15-16, the figures show a decline in the proportion of pupils studying GCSE science between 2001-02 and 2005-06, followed by signs of recovery from 2005-06 to 2009-10. Take-up of the separate sciences grew by almost 150 per cent between 2004-05 and 2009-10.

Figure 3
Trends in GCSE entries in England, 2001-02 to 2009-10

Subject	2001-02 (000s)	2002-03 (000s)	2003-04 (000s)	2004-05 (000s)	2005-06 (000s)	2006-07 (000s)	2007-08 (000s)	2008-09 (000s)	2009-10 (000s)
Single Science	51.8	53.0	55.0	65.5	71.3	67.8			
Double Science	466.3	474.5	479.6	450.9	443.0	434.8			
(counts as two GCSEs)	466.3	474.5	479.6	450.9	443.0	434.8			
Core Science							491.6	456.0	404.9
Additional Science							354.5	324.3	288.5
Additional Applied Science							51.2	47.4	38.5
Biology	40.5	42.6	44.8	48.3	51.8	54.2	74.7	88.0	115.7
Chemistry	39.1	40.9	43.1	45.9	49.2	51.1	68.3	83.1	113.1
Physics	38.6	40.1	42.5	45.4	48.8	50.7	67.3	82.3	112.1
Other sciences	2.8	2.7	2.7	7.7	3.3	15.3	4.9	23.8	21.7
Total science entries	**1,105.4**	**1,128.3**	**1,147.3**	**1,114.6**	**1,110.4**	**1,108.7**	**1,112.5**	**1,104.9**	**1,094.5**
Population aged 15	636.3	655.8	649.7	656.6	667.3	656.6	636.2	628.7	612.1
Total science entries per head of population aged 15	**1.74**	**1.72**	**1.77**	**1.70**	**1.66**	**1.69**	**1.75**	**1.76**	**1.79**

NOTES

1 Single Science entailed a less extensive curriculum and counted as one GCSE.

2 Double Science counted as two GCSEs, hence two sets of figures are shown and counted above.

3 Core and Additional Science / Additional Applied Science replaced Single and Double Science from 2007-08.

4 Maths entry figures are not shown since maths is compulsory at GCSE.

5 2005-06 to 2008-09 entry figures are 'revised', and 2009-10 figures 'provisional'. 2010 population figures are not yet available, hence the 2009 figure for 14-year-olds has been used to estimate the 2010 figure for 15-year-olds.

Source: National Audit Office analysis of Statistical First Releases and Office for National Statistics mid-year population estimates

Achievement at GCSE

2.4 **Figure 4** shows generally rising trends in GCSE achievement in maths and science, including separate sciences, where the improvements were achieved at the same time as increased take-up.

Figure 4
Percentage of GCSE entries in England achieving A*-C

Subject	2001-02 (%)	2002-03 (%)	2003-04 (%)	2004-05 (%)	2005-06 (%)	2006-07 (%)	2007-08 (%)	2008-09 (%)	2009-10 (%)
Single Science	18	16	17	20	20	18			
Double Science	52	53	54	57	57	58			
Core Science							59	61	61
Additional Science							68	67	68
Additional Applied Science							31	34	35
Biology	91	89	90	90	90	90	91	93	94
Chemistry	90	90	90	91	91	92	95	95	94
Physics	90	90	91	91	91	92	94	94	94
Mathematics	52	51	53	55	56	57	59	61	65

NOTE

1 2005-06 to 2008-09 figures are 'revised', and 2009-10 figures 'provisional'.

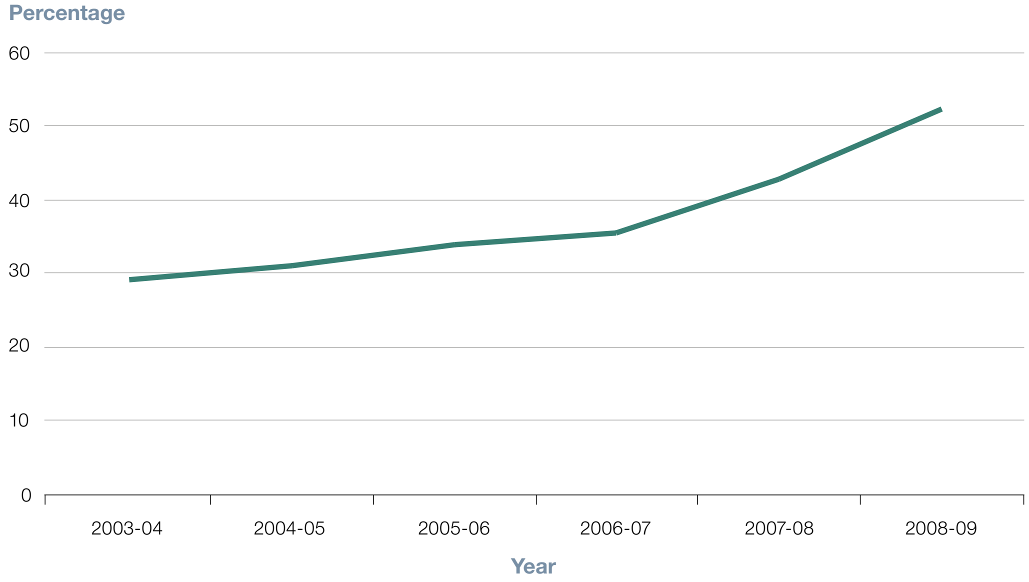
Source: Statistical First Releases

2.5 While Double Science was intended to equip pupils with the necessary knowledge, understanding and skills to study science A-levels, evidence from the Department, academic research[7] and Ofsted[8] suggests that pupils who study three separate sciences ('Triple Science') are more likely to choose and succeed in science at A-level and degree level. Our analysis of the National Pupil Database also indicated that A-level pupils who had previously studied Double Science at GCSE achieved, on average, one grade lower at A-level than those who had studied a separate GCSE in that science.

2.6 The Department has a target that by September 2014, all pupils who would benefit from a more stretching science curriculum have the opportunity to study Triple Science.[9] The number of schools offering Triple Science has increased rapidly in recent years, although by June 2009 almost half of state secondary schools were still not offering pupils this option (**Figure 5**). Detailed data on the number of schools offering Triple Science in 2009-10 is not yet available, but early data on entries to individual sciences suggests that this number has increased further over the last year. Based on provisional 2010 data, the Department believes that a 2014 target for 100,000 maintained school pupils to enter Triple Science at Key Stage 4 will be met early. We consider the distribution and availability of schools offering Triple Science in Part 3.

Figure 5

Percentage of state secondary schools offering Triple Science GCSE, 2003-04 to 2008-09



NOTES

1 Schools are considered to offer Triple Science if at least one student entered physics, chemistry and biology in a single year.

2 Includes maintained secondary schools, academies and city technology colleges (England).

Source: National Audit Office analysis of National Pupil Database

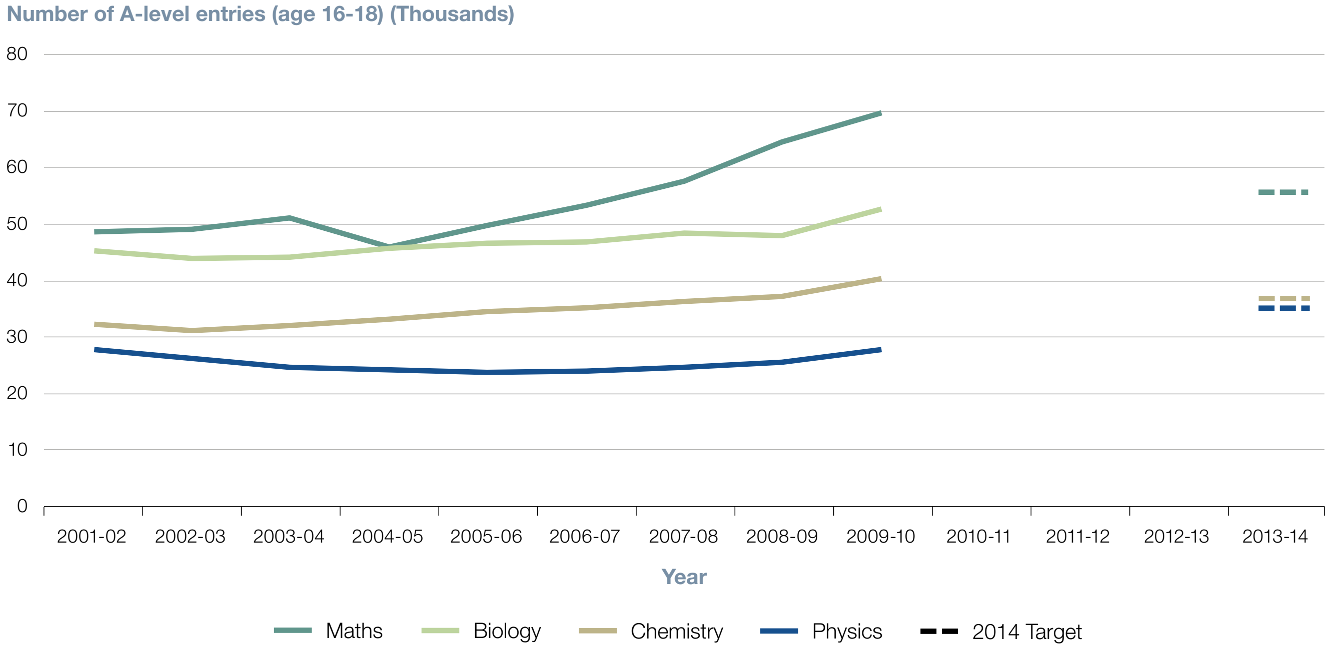
Take-up and achievement at Key Stage 5 (16-18 years)

Take-up at A-level

2.7 In 2005-06, the then Government set a target to achieve year-on-year increases in the number of people taking A-levels in physics, chemistry and maths, so that by 2014 entries to physics would be 35,000 (24,200 at the time), to chemistry 37,000 (33,300 at the time), and to maths 56,000 (46,168 at the time).[10] Although no equivalent was set for biology, the Department has had an internal target to maintain numbers of entries from one year to the next.

2.8 **Figure 6** shows trends in A-level entries in maths and science subjects between 2001-02 and 2009-10. During that period, entries for maths increased to over 10,000 above the original 56,000 target, which the Department has since raised to 80,000. Entries for chemistry also exceeded the 2014 target in 2008-09. Physics entries, while increasing slightly since 2005-06, are currently at only 79 per cent of the 2014 target level. Biology entries have increased by 16 per cent since 2001-02.

Figure 6
Numbers of A-level entries in maths, physics, chemistry and biology, 2001-02 to 2009-10



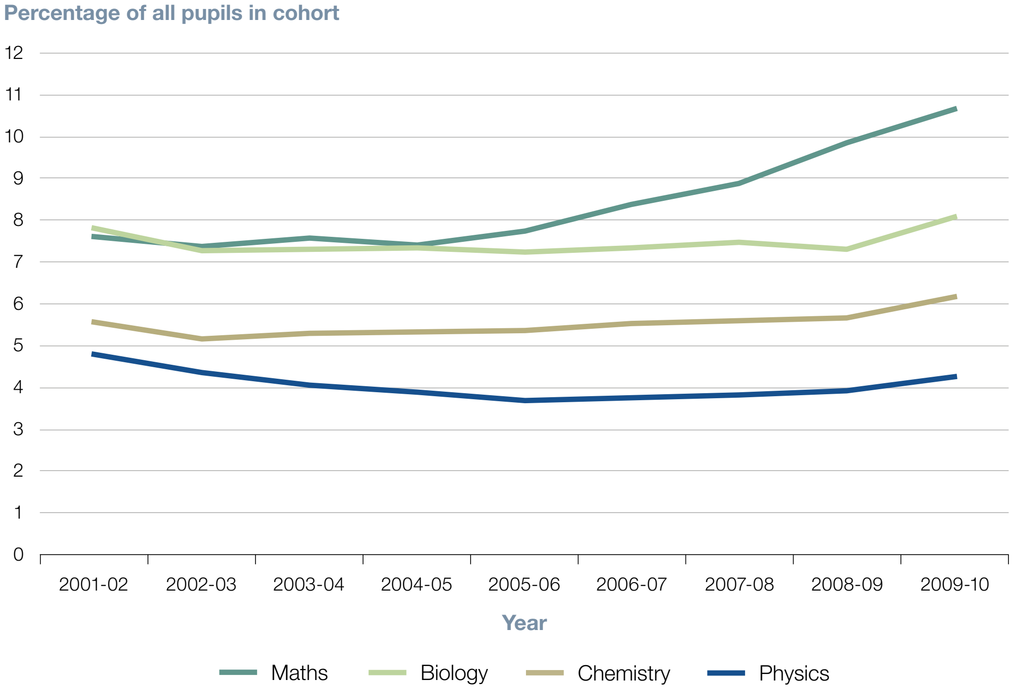
NOTE
1 2009 figures are 'revised', and 2010 'provisional'.

Source: Statistical First Releases

2.9 Figure 7 shows that take-up of A-level maths, chemistry and physics has increased not just in absolute numbers, but also as a proportion of all young people in the relevant age group. Since 2004-05 (the first year covered by the *Science and Innovation Investment Framework*), the proportion of young people choosing maths has increased by over three percentage points. Chemistry has increased by 0.9 percentage points, while physics has increased by only 0.4 percentage points, and remains slightly below its 2002-03 level.

Figure 7

Percentage of former GCSE cohort entering A-levels in maths, physics, chemistry and biology, 2001-02 to 2009-10



NOTE

1 2009 figures are 'revised', and 2010 'provisional'.

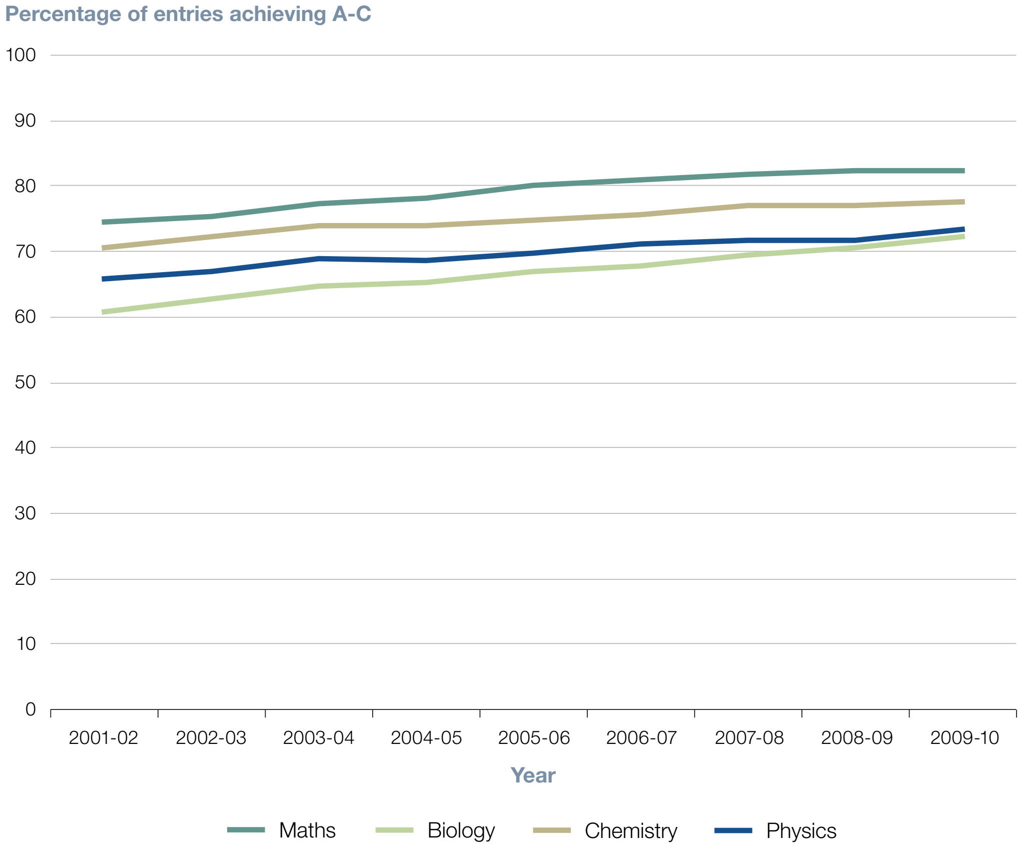
Source: Department for Education

Achievement at A-level

2.10 The proportions of entrants achieving grades A-C in A-level maths, biology, chemistry and physics increased between 2001-02 and 2009-10, with maths rising from 74 to 82 per cent, biology from 61 to 72 per cent, chemistry from 71 to 78 per cent and physics from 66 to 74 per cent (**Figure 8**).

Figure 8

Percentage of entries to A-level maths, physics, chemistry and biology achieving grades A-C, 2001-02 to 2009-10



NOTE

1 2009 figures are 'revised', and 2010 'provisional'.

Source: National Audit Office analysis of Statistical First Releases

Part Three

Improving take-up and achievement in school science and maths

3.1 In this part of the report we evaluate progress in the following areas, identified through our fieldwork as critical success factors to increase take-up and achievement in science and maths:

- careers information and guidance
- quality and quantity of school science facilities
- quality and quantity of science and maths teachers
- image and interest
- availability of separate GCSE sciences ('Triple Science')

We also examine major initiatives aimed at increasing take-up and achievement, and explore their associations at school level with the trends described in Part 2.

Careers information and guidance

3.2 Careers information, advice and guidance available in schools is of variable quality. The need for more effective careers advice was borne out by our survey of 1,274 young people studying both science, technology, engineering and maths subjects and other courses. Only 18 per cent of respondents were satisfied with the careers guidance available to them relevant to science, technology, engineering and maths, and some 50 per cent reported receiving no careers advice, or were unclear what constituted careers advice.[11]

3.3 In 2009, the Department published a strategy on information, advice and guidance for young people[12] aimed at addressing concerns about the training and continuing professional development of careers specialists. The strategy also sets minimum standards for information, advice and guidance available in schools.

3.4 The Department is running a 'Careers awareness timeline pilot', which aims to establish a more coherent structure for young people to learn about careers in science, technology, engineering and maths. Thirty schools are developing and testing activities that link studying science and maths with the knowledge, skills and attitudes relevant to future careers. The pilot is running from May 2008 to March 2011 at a planned cost of £650,000 over the three years. There has not yet been a formal evaluation of the project.

3.5 A further initiative, the *Future Morph* website,[13] aims to increase awareness of the value of studying science and maths among children and young people aged 11-19 by demonstrating potential career opportunities. The project is managed by the Science Council, and the Department contributed start-up costs of £500,000 with matched funding and ongoing support from a variety of other sources. The website was launched in November 2008, with promotion linked to the Science and Maths integrated communications campaign (Figure 26 below). The Department has no specific information on the effectiveness of the website, although traffic is monitored. A formal evaluation by the Science Council will be undertaken in 2011.

Quality and quantity of school science facilities

3.6 Research suggests a positive correlation between the condition of school facilities, the quality of school design, and levels of pupil attainment,[14] and this was supported by our survey of 1,274 children and young people. Around three quarters of respondents currently studying science, technology, engineering or maths said that the availability and quality of teaching equipment played a very influential and important role in their education. Over half of those not studying these subjects said that, with better availability and quality of teaching equipment, they would have been more likely to take them up.

3.7 The 2004-2014 *Science Innovation and Investment Framework* announced a commitment to 'creating a better school environment' by renewing all secondary schools in England (including science provision), and providing capital funding to bring school laboratories up to a satisfactory standard by 2005-06, and to a good or excellent standard by 2010.[15] The 2006 *Next Steps* document reiterated the aim to 'improve the state of school science accommodation by making school science labs a priority'.[16]

3.8 Despite this aim, there is no routinely collected national data covering the quality of school science laboratories, so measuring exact progress against the 2010 target has not been possible. A 2004 survey of maintained secondary schools commissioned by the Royal Society of Chemistry found that of the 26,340 school science laboratories in England, 35 per cent were either 'good' or 'excellent', but 25 per cent were either 'unsatisfactory' or 'unsafe for the teaching of science'.[17] The study found shortages of laboratory space in 3,518 schools in England, estimating that the cost of bringing all secondary school laboratories up to a 'good' rating, through either new build or refurbishment, would be £1.38 billion.

3.9 In 2005, Ofsted confirmed that science accommodation was either unsafe or unsatisfactory in around a quarter of secondary schools,[18] while in a 2007 survey of headteachers from 1,918 state schools in England only 39 per cent rated science laboratories as either good or very good.[19]

3.10 In 2006, a follow-up study for the Royal Society of Chemistry estimated that the average number of laboratories in maintained secondary schools had increased slightly (from 7.5 to 7.9), but that 28 per cent of new or refurbished laboratories were not of an excellent or good standard.[20] The study estimated that, at the rate of progress at the time, the 2010 target for all school laboratories being of excellent standard would not be met until at least 2021.

Quality and quantity of science and maths teachers

3.11 There is evidence that standards of teaching are higher where there is a good match between teachers' initial qualifications and the subjects they teach. For example, Ofsted found that where the match between teachers' qualifications and the subjects they taught was excellent or good, the quality of teaching was excellent/very good/good in 94 per cent of schools, compared to only 22 per cent (all 'good') where the match was unsatisfactory.[21] Demand for specialist teachers is rising, given the more specialist requirements of the Triple Science syllabus, and the increasing numbers taking maths and science at A-level.

3.12 Increasing the number of specialist maths and science teachers in secondary schools was a key aim of the *Science and Innovation Investment Framework 2004-2014: Next Steps*, which set targets to improve teaching and learning through further recruitment and retention of teachers with specialisms in maths, physics and chemistry. The targets required that by 2014, 25 per cent of science teachers will have a physics specialism, 31 per cent a chemistry specialism, and 95 per cent of maths lessons in schools will be delivered by a maths specialist.[22] Progress against these targets is shown in **Figure 9**.

Figure 9
Progress against targets for teaching maths, chemistry and physics

Specialism	2014 Target	2006 baseline (%)[1]	2007 results (%)[2]
Maths	95 per cent of lessons to be taught by a maths specialist	88	84
Chemistry	31 per cent of science teachers to have a chemistry specialism	25	21
Physics	25 per cent of science teachers to have a physics specialism	19	19

Sources:
1 2004-2014 Science and Innovation and Investment Framework: Next Steps (2006), p. 44
2 Department for Education analysis of Secondary Schools Curriculum and Staffing Survey 2007

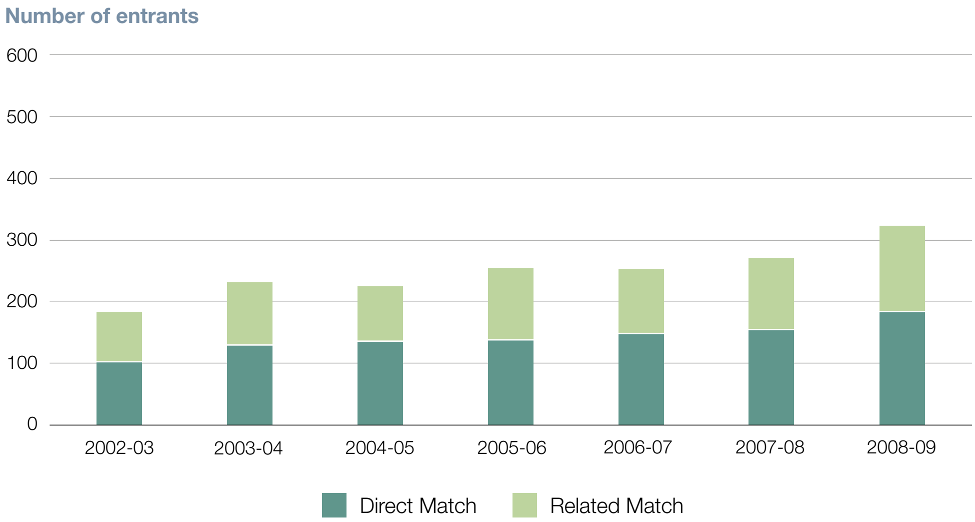
3.13 Robust trend data is not available for years later than 2007, although the Department intends that a new school workforce survey due for publication early in 2011 will show subsequent trends. Based on data from a 2009 pilot of this survey, the Department predicts that of the 2014 targets, the target for chemistry is most likely to be met, while performance in maths and physics will fall short.

3.14 While there has been a rise in absolute numbers of graduates with a physics – or chemistry-related degree entering specialist teacher training (**Figure 10** and **Figure 11**), there has only been a small increase in the percentages of all trainee science teachers with these specialisms, with physics in particular making little progress (**Figure 12**). Since 2008-09, graduates with degrees in related subjects or whose subject knowledge is outdated have been able to undertake Subject Knowledge Enhancement courses in physics, chemistry or mathematics before commencing their Initial Teacher Training. These courses aim to provide them with the more specialist subject knowledge required for teaching these subjects. In 2008-09, 254 future entrants to Initial Teacher Training in physics, and 174 in chemistry, undertook Subject Knowledge Enhancement courses in these subjects.

3.15 One recent programme aimed at increasing recruitment of specialist maths and science teachers is 'Transition to Teaching'. Developed by the Training and Development Agency in conjunction with employers, it aims to promote a teaching career to people in other professions with relevant degrees who are considering a career change. Individuals receive one-to-one support throughout teacher training, including advice on training options, subject knowledge refresher courses, classroom experience and information on funding.

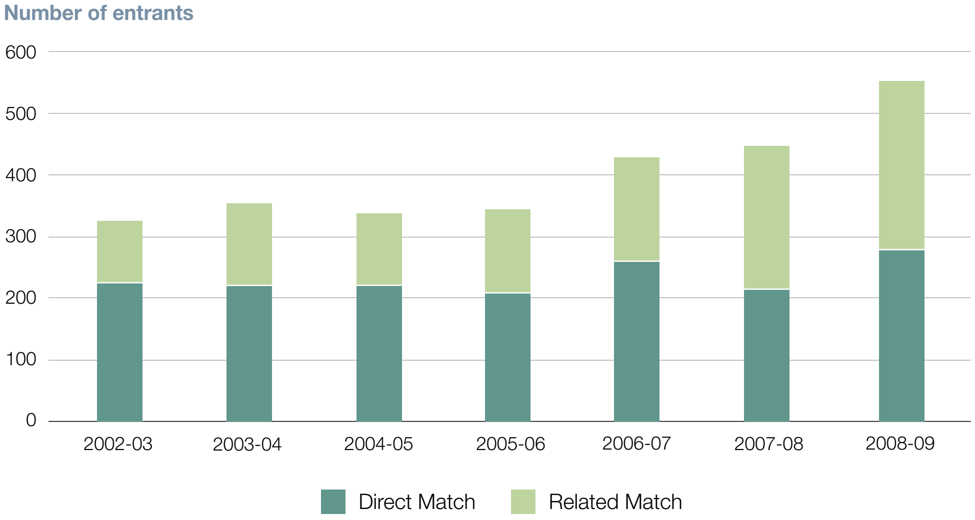
Figure 10

Graduate entrants to Initial Teacher Training in physics who have a direct or related match with their degree specialism



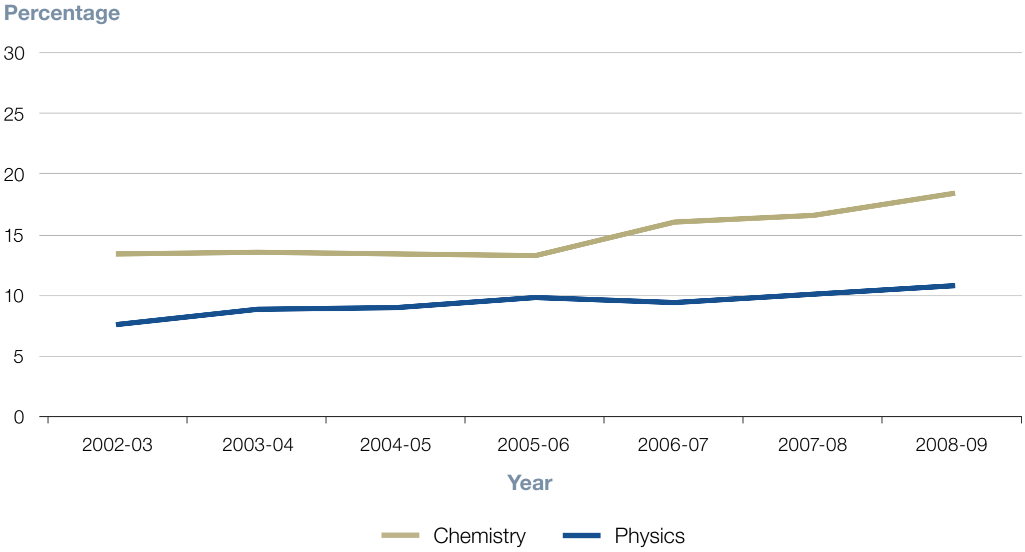
Source: National Audit Office analysis of Training and Development Agency data

Figure 11
Graduate entrants to Initial Teacher Training in chemistry who have a direct or related match with their degree specialism



Source: National Audit Office analysis of Training and Development Agency data

Figure 12
Graduate entrants to Initial Teacher Training in physics and chemistry who have a direct or related match with their degree specialism, as a percentage of all science teacher entrants that year



Source: National Audit Office analysis of Training and Development Agency data

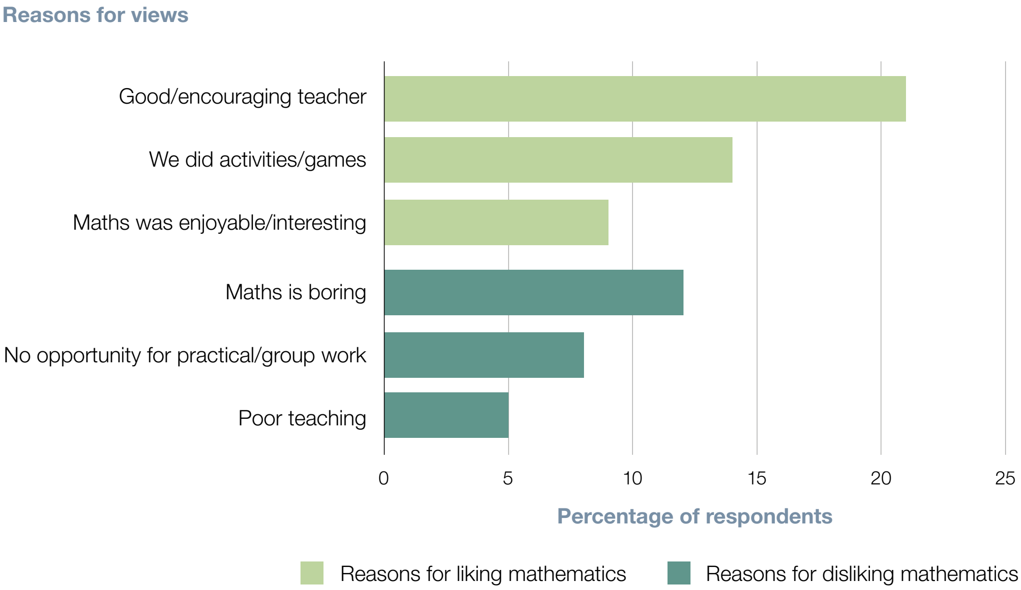
3.16 The programme has initially been funded for three years from May 2008 at a cost of £5 million. In the first year of the programme, only four teachers were trained through this route, although in 2009-10, 46 completed Initial Teacher Training, with a further eight still in training part-time. A total of 174 participants secured a place on Initial Teacher Training for 2010-11, with a further 39 deferring entry to 2011-12. There are currently 892 active participants in the programme, although not all those who participate ultimately make the transition to teaching.

3.17 The economic climate presents an opportunity to maximise the programme's benefits both to potential candidates and to the teaching workforce, since it can potentially form a route from industry into teaching for skilled employees facing redundancy.

Image and interest

3.18 Evidence suggests that a major reason why children and young people give up science and maths is lack of enjoyment and interest.[23] Attitudes are developed from an early age: a survey of young secondary school pupils that we undertook in 2008 identified that the top three reasons for liking and disliking maths at primary school all related to enjoyment, quality of teaching, or both (**Figure 13**).

Figure 13
Top reasons for young secondary school pupils liking or disliking maths



NOTE
1 Base: 1,129 secondary school pupils in years 7 or 8.

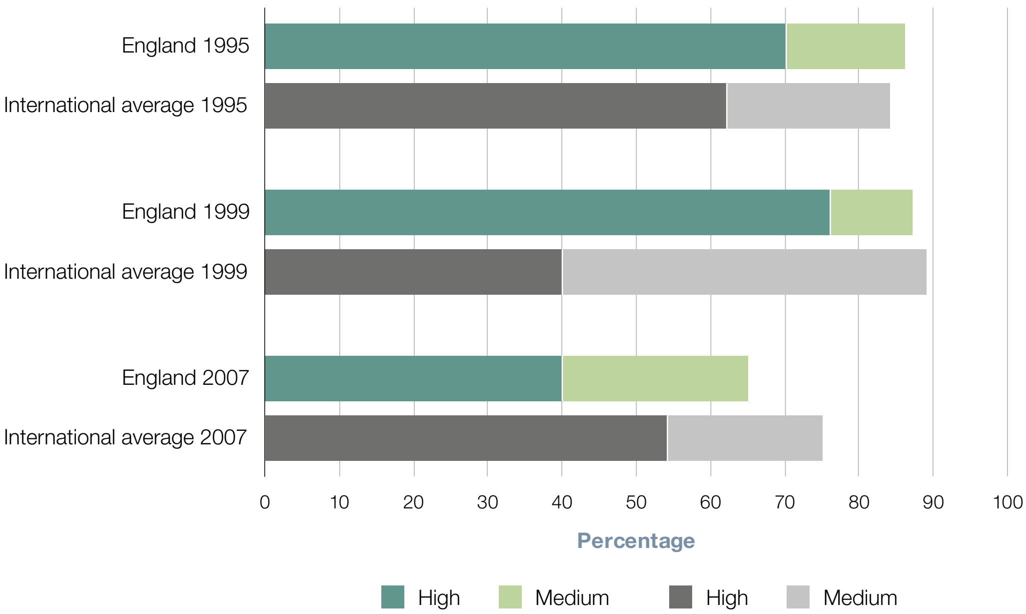
Source: Ipsos MORI Young People Omnibus 2008 conducted for the National Audit Office (Mathematics performance in primary schools: Getting the best results, HC 1151, Session 2007-08, 19 November 2008)

3.19 Seventy-seven per cent of respondents to our survey for the current report said that lack of enjoyment and interest was their main barrier to continuing with science, technology, engineering and maths studies post-GCSE.[24] A 2005 survey of 950 pupils from Years 9, 10 and 11 showed that over 50 per cent found science lessons boring, confusing or difficult,[25] while a 2008 report noted that 27 per cent of people under 24 claimed science at school had a detrimental effect on their interest.[26]

3.20 The Trends in International Mathematics and Science Study (TIMSS) is a worldwide research project which takes place every four years and provides data about school maths and science in various countries. In addition to examining achievement and curriculum, it explores how positively young people feel towards maths and science, how much they value them and how confident they feel learning them.

3.21 TIMSS analysis uses pupils' responses to create a single measure of 'positive affect' (in effect, how positively they feel towards the subject). Pupils are categorised into three bands: high, medium and low. The percentage of 14-year-olds in England reporting a medium or high 'positive affect' to maths decreased by some 20 percentage points between 1995 and 2007, dropping to around ten percentage points below the international average (**Figure 14**). There was a particularly sharp decline (around 30 percentage points) in the proportion of pupils in England with a high 'positive affect' to maths.

Figure 14
Percentage of 14-year-olds with a 'positive affect' to maths



NOTE
1 1995, 1999 and 2007 international averages are based on 18, 22 and 49 countries respectively.

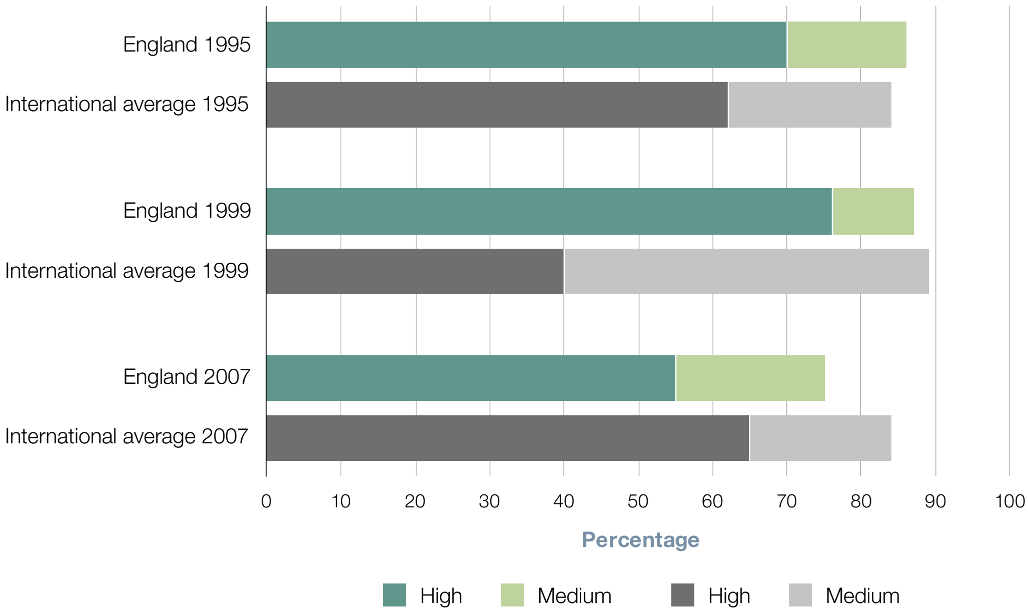
Source: Trends in International Mathematics and Science Studies (TIMSS), 1995-2007

3.22 Figure 15 shows a similar trend for science subjects, with the previously large proportions of young people with a high 'positive affect' to science decreasing by 20 percentage points between 1999 and 2007, and finishing around ten percentage points below the international average.

3.23 TIMSS studies also collect data on children's self-confidence in learning maths and science. As **Figure 16** shows, 14-year olds in England have higher levels of self-confidence in learning maths than the international average, with 81 per cent of pupils in England reporting medium or high self-confidence in 2003, increasing to 85 per cent in 2007 (the international average was 78 and 80 per cent respectively). The equivalent figures for science also compare favourably with the international average in both 2003 and 2007 (**Figure 17**).

Figure 15

Percentage of 14-year-olds with a 'positive affect' to science

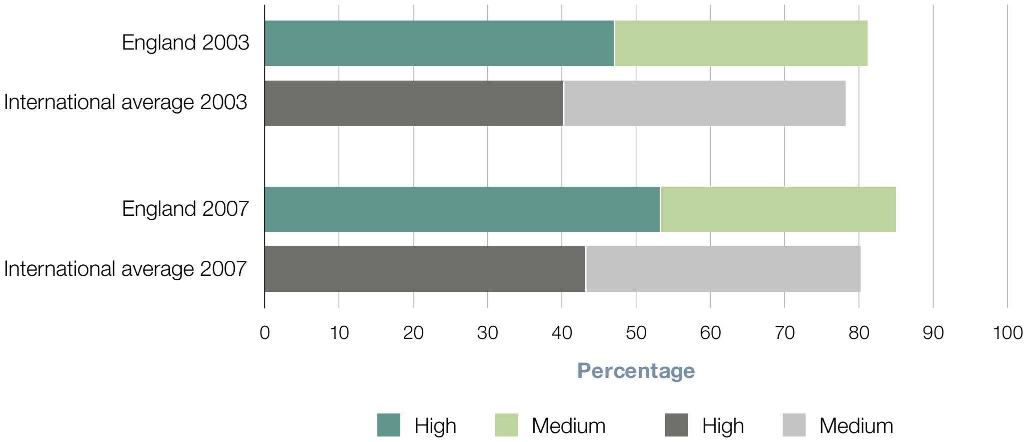


NOTE

1 1995, 1999 and 2007 international averages are based on 31, 30 and 50 countries respectively.

Source: Trends in International Mathematics and Science Studies (TIMSS), 1995-2007

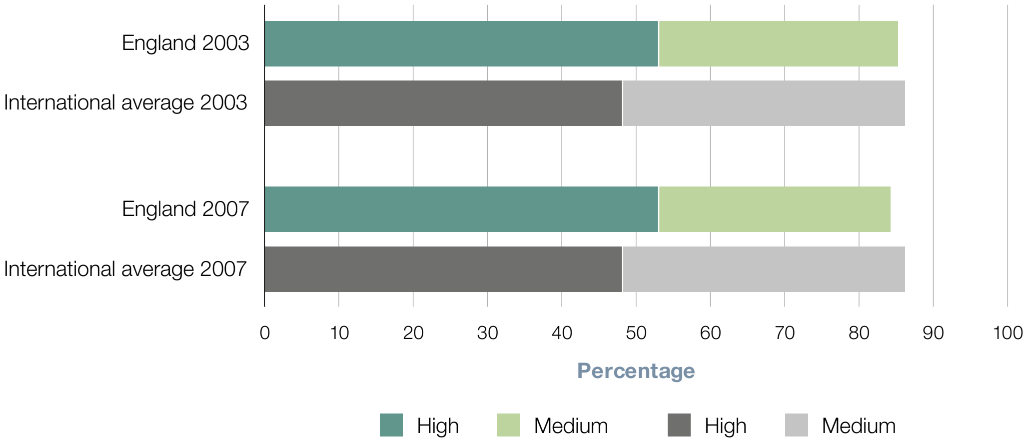
Figure 16
Percentage of 14-year-olds with a high level of self-confidence learning maths



NOTE
1 2003 and 2007 international averages are based on 45 and 49 countries respectively.

Source: Trends in International Mathematics and Science Studies (TIMSS), 2003-2007

Figure 17
Percentage of 14-year-olds with a high level of self-confidence learning science

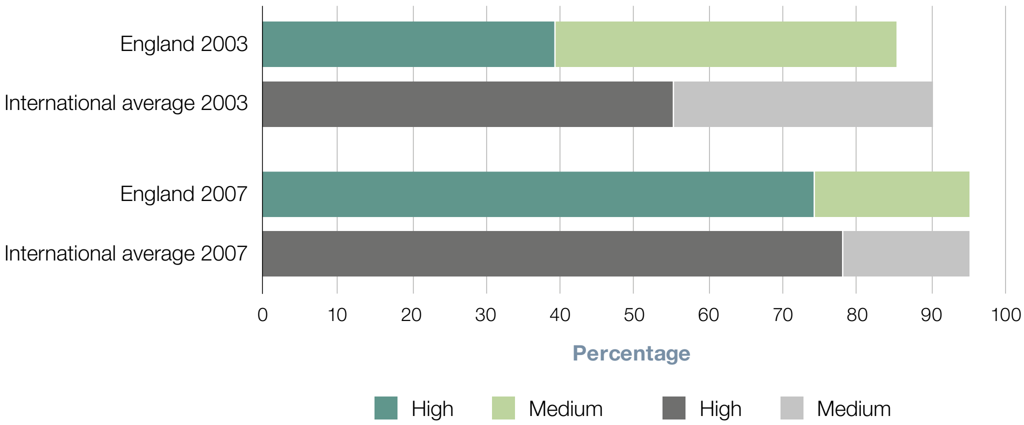


NOTE
1 2003 and 2007 international averages are based on 27 and 29 countries respectively.

Source: Trends in International Mathematics and Science Studies (TIMSS), 2003-2007

3.24 TIMSS also explores the ‘value’ pupils place on maths and science. It uses a composite index based on pupils’ views as to whether these subjects help them in daily life, and are necessary for learning other subjects, getting into the university of their choice and obtaining the job they want. In the case of maths, England has improved, with 95 per cent of 14 year-olds placing a medium or high value on the subject in 2007 (**Figure 18**). For science, England remains six percentage points below the international average, although the gap closed by two percentage points between 2003 and 2007 (**Figure 19**).

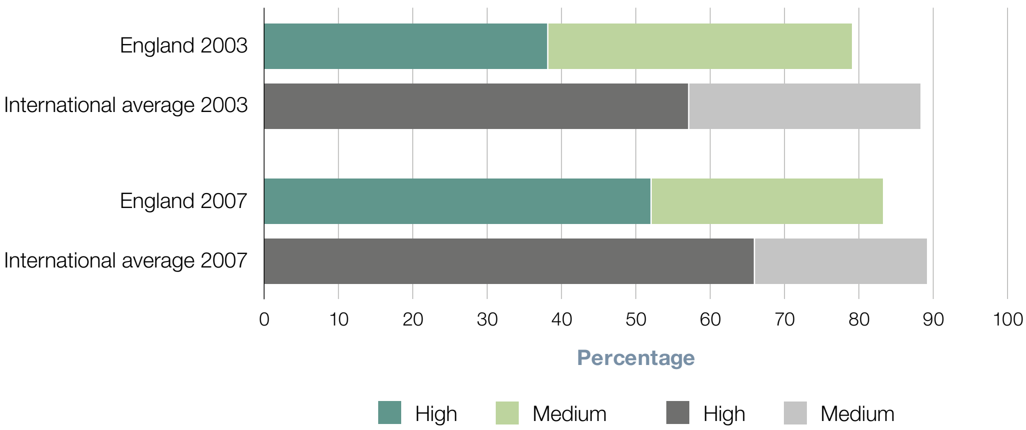
Figure 18
Index of 14-year-olds valuing maths



NOTE
1 2003 and 2007 international averages are based on 46 and 49 countries respectively.

Source: Trends in International Mathematics and Science Studies (TIMSS), 2003-2007

Figure 19
Index of 14-year-olds valuing science



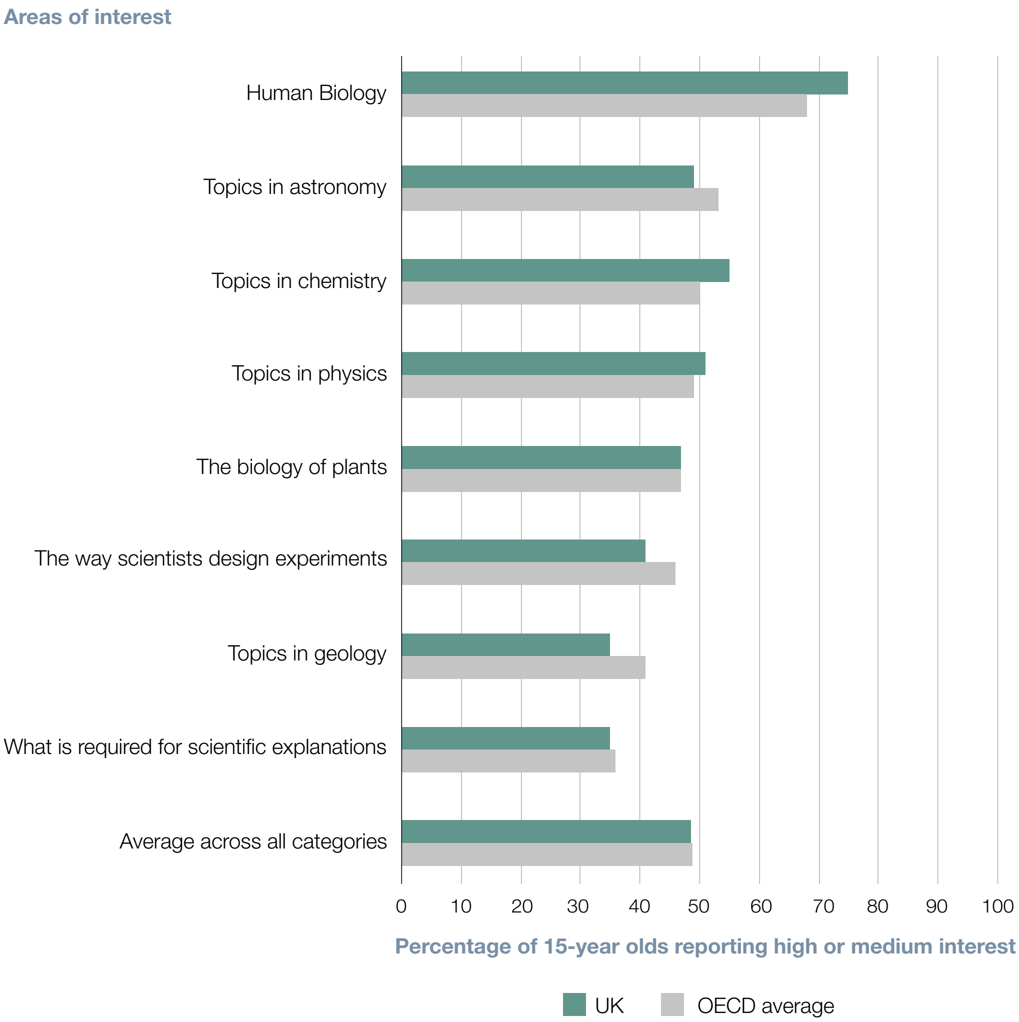
NOTE
1 2003 and 2007 international averages are based on 40 and 50 countries respectively.

Source: Trends in International Mathematics and Science Studies (TIMSS), 2003-2007

3.25 The TIMSS findings are echoed by the other major international research project on young people's views of science, the Organisation for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA). In 2006, PISA gathered views on science from over 400,000 15-year olds in 57 countries, covering areas such as general interest (**Figure 20**), enjoyment (**Figure 21** overleaf), and motivation to pursue science both now ('instrumental motivation', **Figure 22** on page 33) and in the future ('future-orientated motivation', **Figure 23** on page 34). The UK compares well for general interest (particularly in human biology and chemistry), in some aspects of enjoyment and in most aspects of instrumental motivation. It does less well in aspects of future motivation such as working in science as an adult, and is also some eight percentage points behind the OECD average on whether pupils 'generally have fun when learning about science topics'.

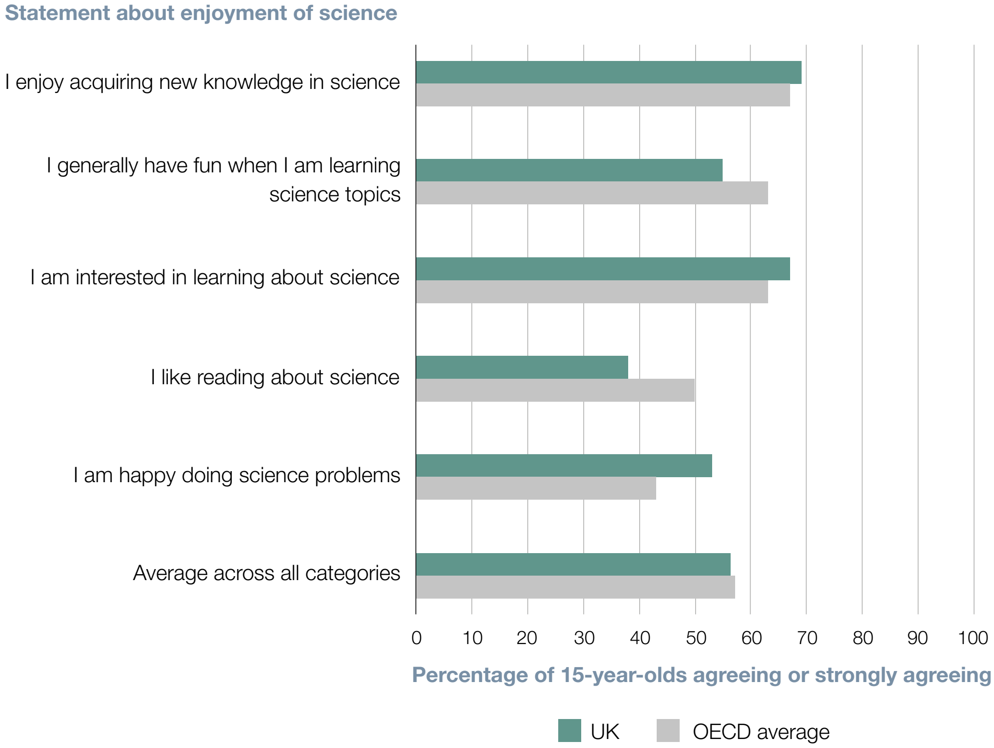
Figure 20

Findings of the 2006 OECD Programme for International Student Assessment on 15-year-olds' general interest in science



Source: OECD PISA data (2006)

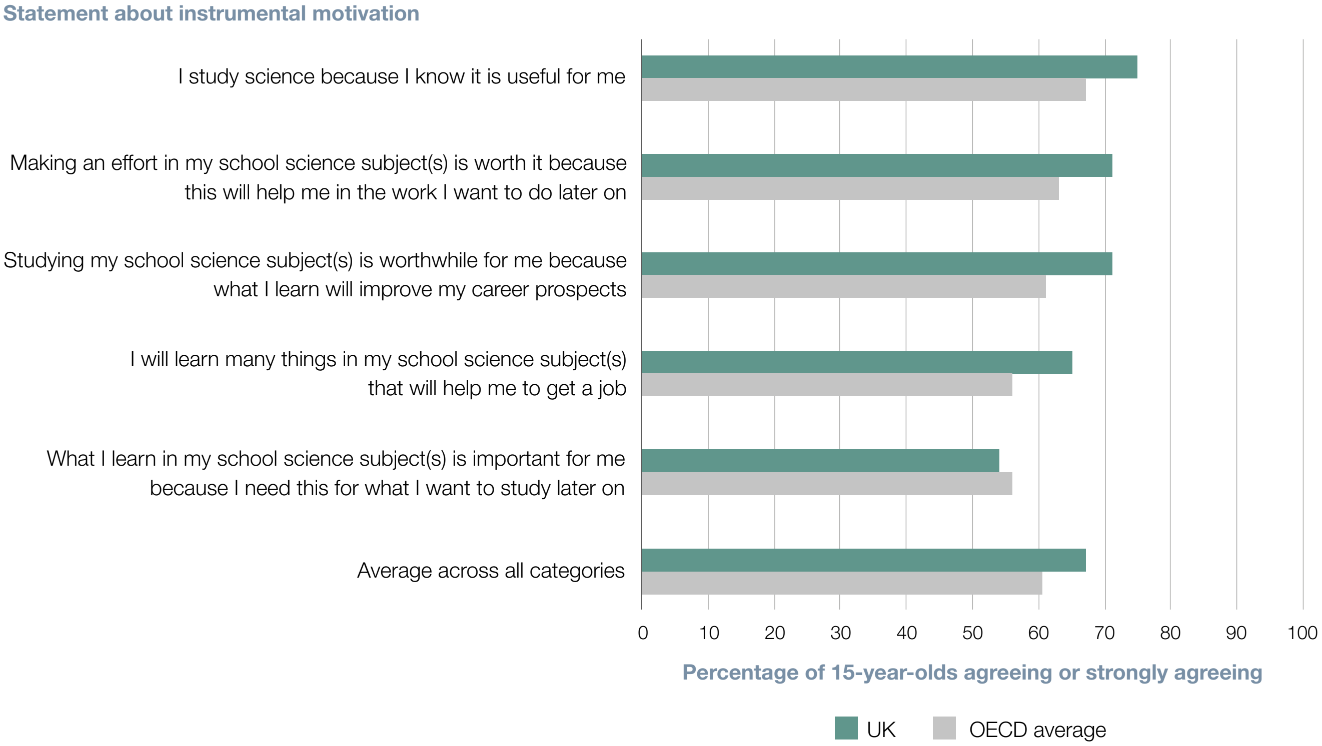
Figure 21
Findings of the 2006 OECD Programme for International Student Assessment on 15-year-olds' enjoyment of science



Source: OECD PISA data (2006)

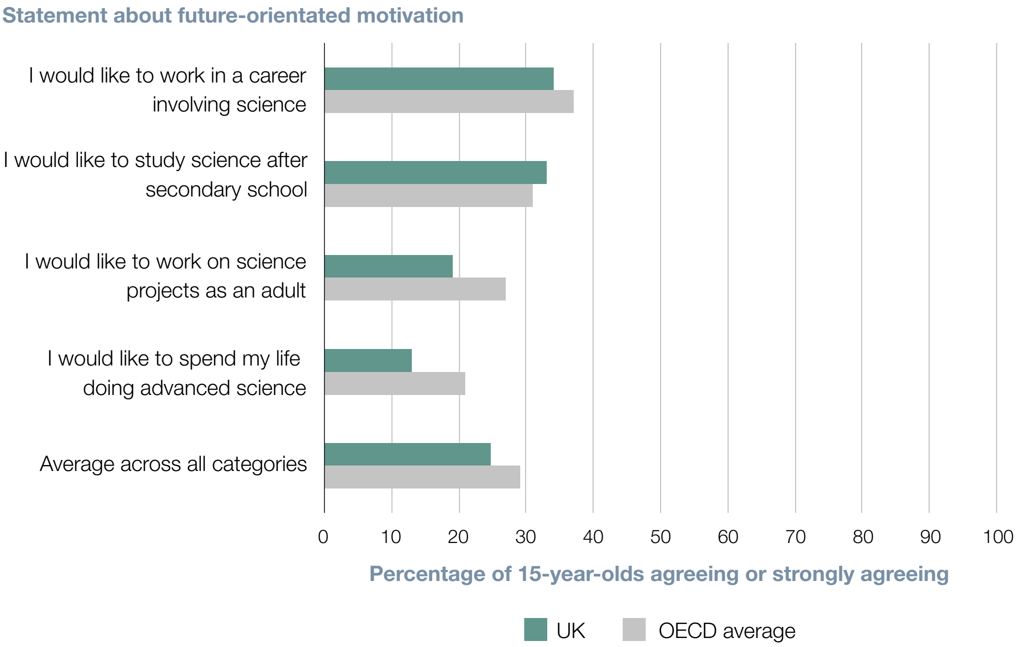
Figure 22

Findings of the 2006 OECD Programme for International Student Assessment on 15-year-olds' instrumental motivation regarding science



Source: OECD PISA data (2006)

Figure 23
Findings of the 2006 OECD Programme for International Student Assessment on 15-year-olds' future-orientated motivation to learn science



Source: OECD PISA data (2006)

Availability of Triple Science GCSE

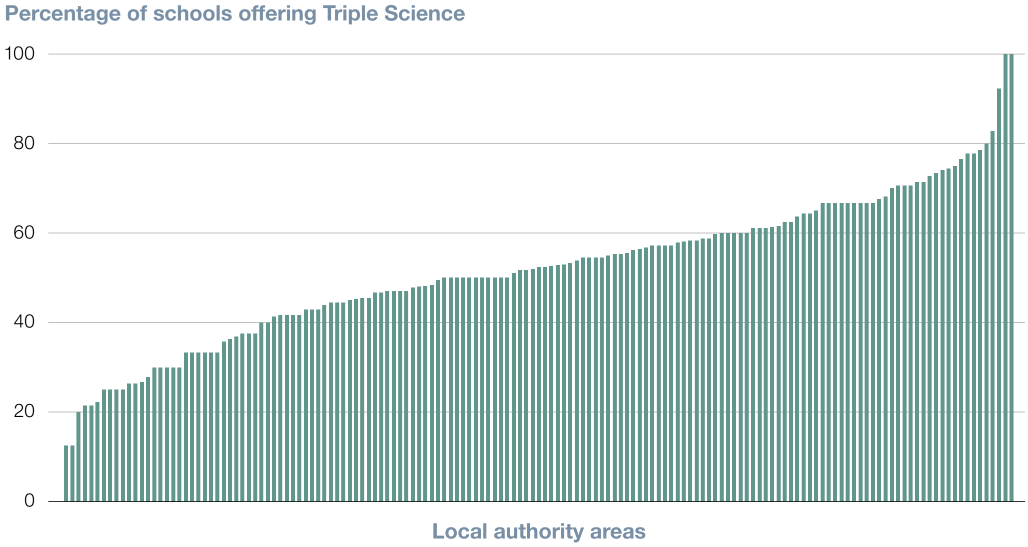
3.26 The Department is making good progress nationally against its target of making Triple Science available to all pupils by 2014 (paragraph 2.6). However, there are wide variations across local authority areas. For example, in 2008-09 almost half of local authority areas had 50 per cent or fewer of schools offering Triple Science, and only two areas had it available in every school (**Figure 24**).

3.27 Research shows that compared with other pupils, pupils from more deprived backgrounds achieve relatively larger improvements in their future A-level science and maths outcomes when offered Triple Science at GCSE than when offered only combined science.[27] However, our analysis shows a statistically significant negative correlation between an area's level of deprivation[28] and the availability of Triple Science, suggesting that this more specialised curriculum is lacking in the areas where it could have the greatest impact on take-up and achievement.

3.28 Strongly correlated with the availability of Triple Science is the provision of secondary schools with a specialism in science, technology, engineering or maths and computing, of which there are currently around 1,300 in England. Our analysis suggests that on average over six per cent more pupils at these schools achieve A*-C at GCSE science than at other state secondary schools (Figure 27), and over two per cent more an A-C in A-level maths, biology, physics or chemistry (Figure 28 and Figure 29). However, there are wide variations in provision between local authorities (**Figure 25** overleaf), again with a negative correlation between level of deprivation and the availability of such specialist schools.

Figure 24

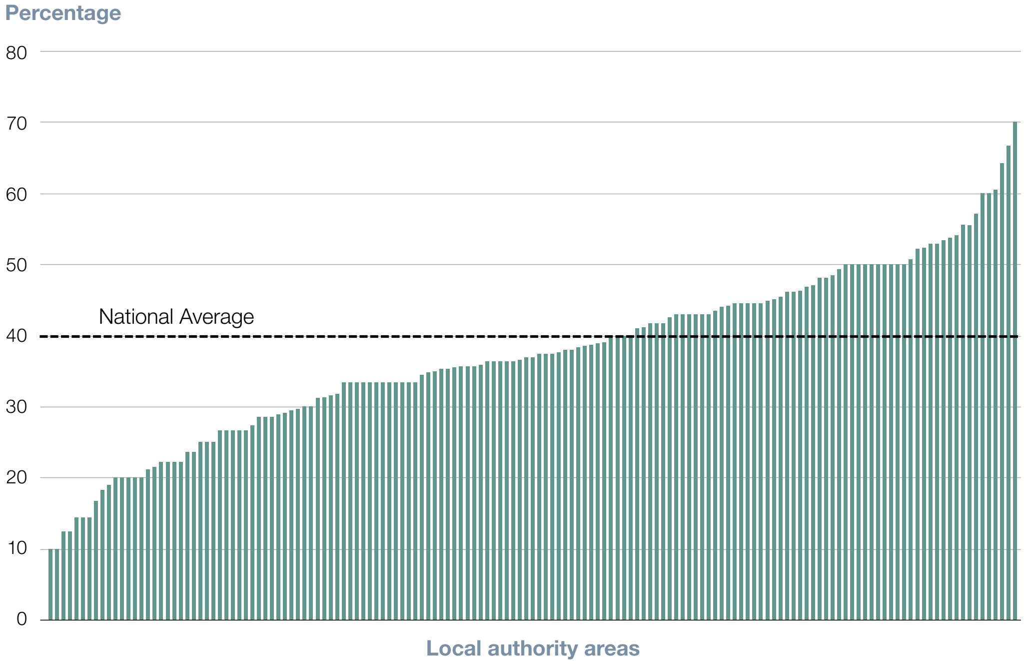
Proportion of state secondary schools offering Triple Science GCSE in each local authority area in England in 2008-09



Source: National Audit Office analysis of National Pupil Database

Figure 25

Percentage of state secondary schools with a specialism in science, technology, engineering or maths and computing in each local authority area in England in 2008-09



Source: National Audit Office analysis of Department for Education data

Effectiveness of programmes to improve take-up and achievement in science and maths

3.29 A 2004 review[29] of science- and maths-related initiatives for children and young people up to age 18 identified 120 led by the Department, 217 run through other government departments and/or partners, and another 141 provided through external organisations. Nearly two thirds had had no evaluation or no evaluation was planned.

3.30 Acknowledging the risk of duplication and inefficiency associated with such a high number of initiatives, a national programme was developed from 2006 with the aim of rationalizing the support for schools that receives national funding and endorsement.[30] As part of this process, the STEMNET[31] organisation has a role in brokering science, technology, engineering and maths-related enhancement and enrichment activities for schools and colleges.

3.31 Figure 26 overleaf outlines recent major government-funded programmes aimed at improving take-up and achievement in science, technology, engineering and maths subjects. Some of these programmes have been evaluated. For example, a tracking exercise for the 'Science and maths integrated communications campaign' showed that 44 per cent of pupils interviewed had seen the advertising. The proportion of pupils very likely to take or definitely taking A-level maths increased from 52 to 65 per cent, though there was no significant change for technology, engineering, biology, chemistry or physics. The campaign had changed the opinion of 41 per cent of parents about their child taking science or maths at A-level.

3.32 A key aim of the *Science and Innovation Investment Framework* is increased take-up of subject-specific continuing professional development by maths and science teachers.[32] An Ofsted review of science teaching between 2004 and 2007 identified shortfalls in teachers' continuing professional development in science,[33] and a 2006 research study suggested that approximately 50 per cent of all secondary school science teachers had had no subject knowledge-related continuing professional development in the previous five years.[34] Science Learning Centres and the National Centre for Excellence in Teaching Mathematics are the major response to the need to improve continuing professional development for maths and science teachers.

3.33 To explore the associations between the programmes above and take-up and achievement in science and maths, we performed a number of regression analyses. These compared schools' participation in the activities with their current level of take-up and achievement at GCSE and A-level, as well as the percentage point change in take-up and achievement between 2004-05 and 2008-09. The activities tested[35] were:

Pupil-based

- Enhancement and Enrichment activities
- STEM Clubs
- STEM Ambassador activities
- Crest Awards
- Research Councils UK 'Researchers in Residence' scheme
- 'More Maths Grads'
- 'Stimulating Physics'
- 'London Engineering Project'

Teacher-based

- Training days in Regional Science Learning Centres
- Training days in the National Science Learning Centre
- Triple Science Networks

Figure 26

Major government-funded programmes aimed at improving take-up and achievement in school maths and science

Intervention	Description	Funding source	Expenditure
STEM Brokerage	Delivered by regional contractors for STEMNET, brokerage involves providing schools and colleges with impartial advice on Enhancement and Enrichment activities.	Department for Business, Innovation and Skills (BIS)	£12.7m for six years to 2010-11
Enhancement and Enrichment activities	Activities intended to complement the science, technology, engineering and maths curriculum and motivate young people to pursue related education and careers.	Where not free at source, funded by schools and/or parents	Estimated £1.0m across state secondary schools in England (Source: NAO analysis of average scheme costs and take-up in 2008-09)
STEM Clubs	Managed by STEMNET, intended to offer an engaging programme of activities to schoolchildren with interest and potential in science. In October 2007, the Department announced its intention to establish a club in every secondary school within five years. As at October 2010 there were 1,469 clubs, covering 47 per cent of all secondary schools.	The Department	£9.1m for four years to 2010-11
'STEM Ambassadors'	Recruited and administered by STEMNET, STEM Ambassadors are intended to improve young people's perception of science by bringing them into contact with positive role models from science, maths, engineering and technology backgrounds. A total of 27,000 ambassadors are expected by April 2011. As at October 2010 there were 24,315.	BIS	£10.7m for six years to 2010-11
'STEM Pathfinder Programme'	A programme managed by the Specialist Schools and Academies Trust, intended to support networks of specialist schools to design and deliver integrated STEM activities through a programme of continuing professional development (CPD) and other resources.	The Department	£0.6m for two years to 2009-10
Science Learning Centres	A network of facilities comprising one National Science Learning Centre covering the entire UK, and nine regional centres for England. They offer a variety of courses aimed at enhancing the professional skills of STEM educators.	Jointly by the Department and the Wellcome Trust[1]	National centre: Three years to 2008: Contribution from Wellcome Trust of £11m to building costs; and £9m to running costs, with 0.6m from the Department From 2008 to 2013, £10m from Wellcome Trust towards core running costs, including delivering 'Project Enthuse' (below) Regional centres: £25.4m from the Department for 3 years to March 2008; £18m from the Department for 3 years to March 2011
National Science Learning Centre: Project ENTHUSE	From July 2008, bursaries for which teachers from every maintained school in the UK can apply, covering fees, travel and accommodation for individual teachers, as well as the cost to schools of providing teaching cover.	Jointly by the Department and industry partners	£17m in bursaries over 2008 to 2013, including £10m from the Department and £7m from industry partners
The National Centre for Excellence in the Teaching of Mathematics	Aims to support and encourage maths-specific CPD by providing and signposting resources through the Internet and a network of Regional Coordinators. Funds and publishes school-based research into effective maths teaching practices and CPD.	The Department	£16.9m for four years to 2010-11
Triple Science Support Networks	Collaborative networks intended to support the implementation and delivery of Triple Science in schools by offering knowledge, materials, training, support and advice.	The Department	£9m for three years to 2010-11
CREST Awards	Britain's largest national award scheme for project work in science, technology, engineering and maths subjects. It is intended to give young people aged 11-19 opportunities to explore real-world projects in an exciting way.	The Department and BIS	£1m for two years to 2010-11
Research Councils UK Researchers in Residence scheme	Placement of early-career researchers in secondary schools and further education colleges, intended to enrich the classroom experience, engage young people with real-life research and give researchers the opportunity to develop new skills.	Research Councils UK with support from the Wellcome Trust	£1.2m for three years to 31 July 2009; £1.4m for three years to 31 July 2012 (Wellcome Trust contribution: £0.085m)
'More Maths Grads'	A three-year pilot intended to develop, trial and evaluate means of increasing the number of pupils studying maths and maths-rich courses, and encouraging participation from learners not traditionally well represented in higher education.	Higher Education Funding Council for England (HEFCE)	£3.1m for three years to 2010
'Stimulating Physics'	A three-year pilot aimed at increasing the numbers of pupils taking physics at A-level and progressing onto a degree in physics.	HEFCE	£1.8m from May 2006 to April 2008 £1.125m from April 2008 to July 2009
'Chemistry for our Future'	A three-year pilot aimed at ensuring a sustainable chemical science base within higher education, attracting able students from all backgrounds and providing chemical science courses appropriate for the 21st Century.	HEFCE	£3.6 million from September 2006 to August 2008 £1.65 million from September 2008 to July 2009
London Engineering Project	A partnership of schools, colleges, universities, science and engineering education charities, industry and government, running outreach activities in schools, as well as developing further and higher education links and courses.	HEFCE	£2.85m from September 2005 to March 2008 £1.52m from March 2008 to July 2009
Science and mathematics integrated communications campaign	From March 2008, a three-year campaign designed to engage pupils aged 11-16 and increase numbers taking science and maths A-levels. Includes a page on the Bebo social networking site, cinema advertisements and press articles.	The Department	£3m over three years to 2011.

NOTE

1 The Wellcome Trust is an independent charity funding research to improve human and animal health.

Source: National Audit Office document review and discussion with key stakeholders

Associations between use of interventions and take-up and achievement

3.34 At GCSE we considered take-up and achievement in the separate sciences: biology, chemistry and physics. The number of pupils taking these subjects at schools is very highly correlated, and therefore the results of our analysis are similar across the three sciences. At A-level, we considered take-up and achievement both in the three sciences and in maths.

3.35 Our analysis showed that these programmes explain only a very small proportion of the variation in exam trends.[36] The rest is likely to be attributable to other more influential factors, such as pupil intake.

3.36 Our analysis indicated that, considered separately, a number of these programmes were associated with higher absolute take-up, greater increases in take-up over time and higher achievement. However, since many schools are participating in more than one programme, it is difficult to isolate how much of the improvement is associated with one particular intervention, rather than with others accessed at the same time. We therefore ran a multiple regression exploring the extent to which each intervention was associated with changes in take-up and achievement when used in combination with others. We also included a variable for whether schools had a specialism in science, technology, engineering or maths and computing, since this was likely to be a key factor associated with take-up and achievement in related subjects.

3.37 In addition to specialist school status, three interventions were associated with statistically significant increases in numbers of pupils achieving grades A*-C in GCSE sciences (**Figure 27**).

Figure 27

Difference between percentage of pupils achieving A*-C in separate GCSE sciences at schools with and without interventions

Intervention (units of measurement for which percentage change is reported are shown in brackets)	**Additional per cent of pupils achieving GCSE science A*-C in 2008-09 in schools with interventions**	**Additional increase between 2004-05 and 2008-09 in the percentage of pupils achieving GCSE science A*-C in schools with interventions**
Enhancement and Enrichment Activities (per activity)	0.245	0.252
STEM Ambassador activities (per activity)	0.525	–
Training days in National Science Learning Centre (per day)	0.136	0.099
Specialism in science, technology, engineering or maths and computing	6.342	2.808

NOTES

1 The GCSE data cited are for biology, but the results are strongly correlated across biology, chemistry and physics.

2 '–' indicates that results were not statistically significant.

Source: National Audit Office analysis of National Pupil Database and school-level intervention data

3.38 The equivalent results for A-level are shown below. In addition to specialist school status, two interventions had positive results that were statistically significant for pupils achieving grades A-C (**Figure 28**).

3.39 For A-level maths, three interventions in addition to specialist school status were associated with statistically significant increases in numbers of pupils achieving grades A-C (**Figure 29**).

Figure 28

Difference between percentage of students achieving A-C in A-level science in schools with and without interventions

Intervention (units of measurement for which percentage change is reported are shown in brackets)	**Additional per cent of pupils achieving science A-level A-C in 2008-09 in schools with interventions**	**Additional increase between 2004-05 and 2008-09 in the percentage of pupils achieving science A-level A-C in schools with interventions**
Enhancement and Enrichment Activities (per activity)	0.172	–
STEM Ambassador activities (per activity)	0.213	–
Specialism in science, technology, engineering or maths and computing	2.122	0.470

NOTES

1 The A-level data cited are for biology, but the results are strongly correlated across biology, chemistry and physics.

2 '–' indicates that results were not statistically significant.

Source: National Audit Office analysis of National Pupil Database and school-level intervention data

Figure 29

Difference between percentage of students achieving A-C in A-level maths in schools with and without interventions

Intervention (units of measurement for which percentage change is reported are shown in brackets)	**Additional percentage of pupils achieving A-level maths A-C in 2008-09 in schools with interventions**	**Additional increase between 2004-05 and 2008-09 in the percentage of pupils achieving A-level maths A-C in schools with interventions**
Enhancement and Enrichment Activities (per activity)	0.218	0.064
STEM Ambassador activities (per activity)	0.320	–
Research Councils UK Researchers in Residence scheme (per researcher)	1.259	0.927
Specialism in science, technology, engineering or maths and computing	2.968	1.009

NOTE

1 '–' indicates that results were not statistically significant.

Source: National Audit Office analysis of National Pupil Database and school-level intervention data

3.40 The findings above are broadly consistent with other evaluations of some of the programmes. For example, 80 per cent of science educators who participated in a Science Learning Centre course during 2007-08 felt it had a positive impact on their personal motivation, and 90 per cent were satisfied with the quality of training received.[37] In a similar survey in 2008-09, 82 per cent of participants reported that pupils had access to new and better learning activities, 73 per cent said that pupil motivation had improved, and 56 per cent indicated an improvement to pupil learning.[38]

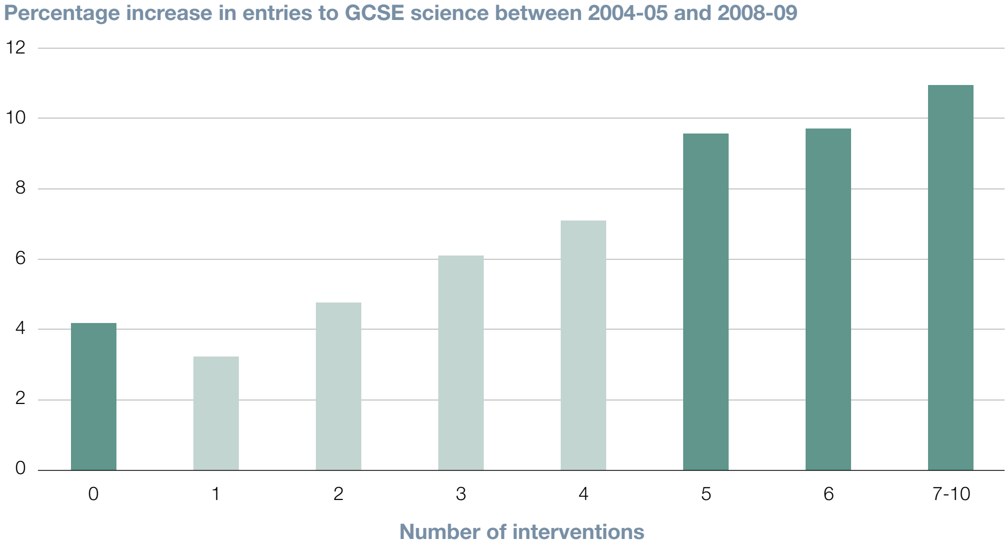
3.41 The other initiatives we tested were not as yet associated with statistically significant changes in achievement and take-up, although this does not necessarily mean that they are ineffective or cannot support future improvements. The incompleteness of activity data from some of the programmes, as well as the relatively short timeframes and difficulty of establishing causal links to take-up and achievement, mean that more evaluation is required to conclude on longer-term effectiveness.

Maximising the benefits of existing interventions

3.42 Our analysis suggests that the interventions outlined above are associated with improved take-up and achievement in science and maths, but that they could be rationalised and provided to schools in a more systematic way. To explore the question of how many intervention types a school might use for optimum cost-effectiveness, we ran an additional regression model. This considered the percentage point increase in pupils taking separate GCSE science subjects associated with each number of activities. The results suggest that take-up of GCSE sciences is proportionally associated with the number of different programmes in which schools participate (**Figure 30**). However, there may be diminishing returns when schools access larger numbers of interventions with similar objectives.

3.43 A small proportion of schools are currently accessing few or none of the major programmes considered here (**Figure 31**), with variations in take-up across different regions, particularly of STEMNET activities and teacher-based interventions such as Science Learning Centres (**Figure 32** on page 44). The proportion of schools not using any teacher-based activities ranges from under 1 per cent in one region (North East) to almost 11 per cent in another (West Midlands).

Figure 30
Numbers of intervention types and their association with the percentage of pupils taking GCSE science subjects



NOTE

1 The dark green bars represent statistically significant differences between schools with the relevant number of interventions and schools with no interventions.

Source: National Audit Office analysis of National Pupil Database and intervention activity data

Figure 31
Proportions of schools not receiving different intervention types

	Percentage of state secondary schools
Not using any of the activities considered (paragraph 3.33)	2
Not using any teacher-based activities (paragraph 3.33)	8
Not using any pupil-based activities (paragraph 3.33)	4
Not using any core STEMNET activities (Enhancement and Enrichment, 'STEM Clubs' and 'STEM Ambassadors')	12

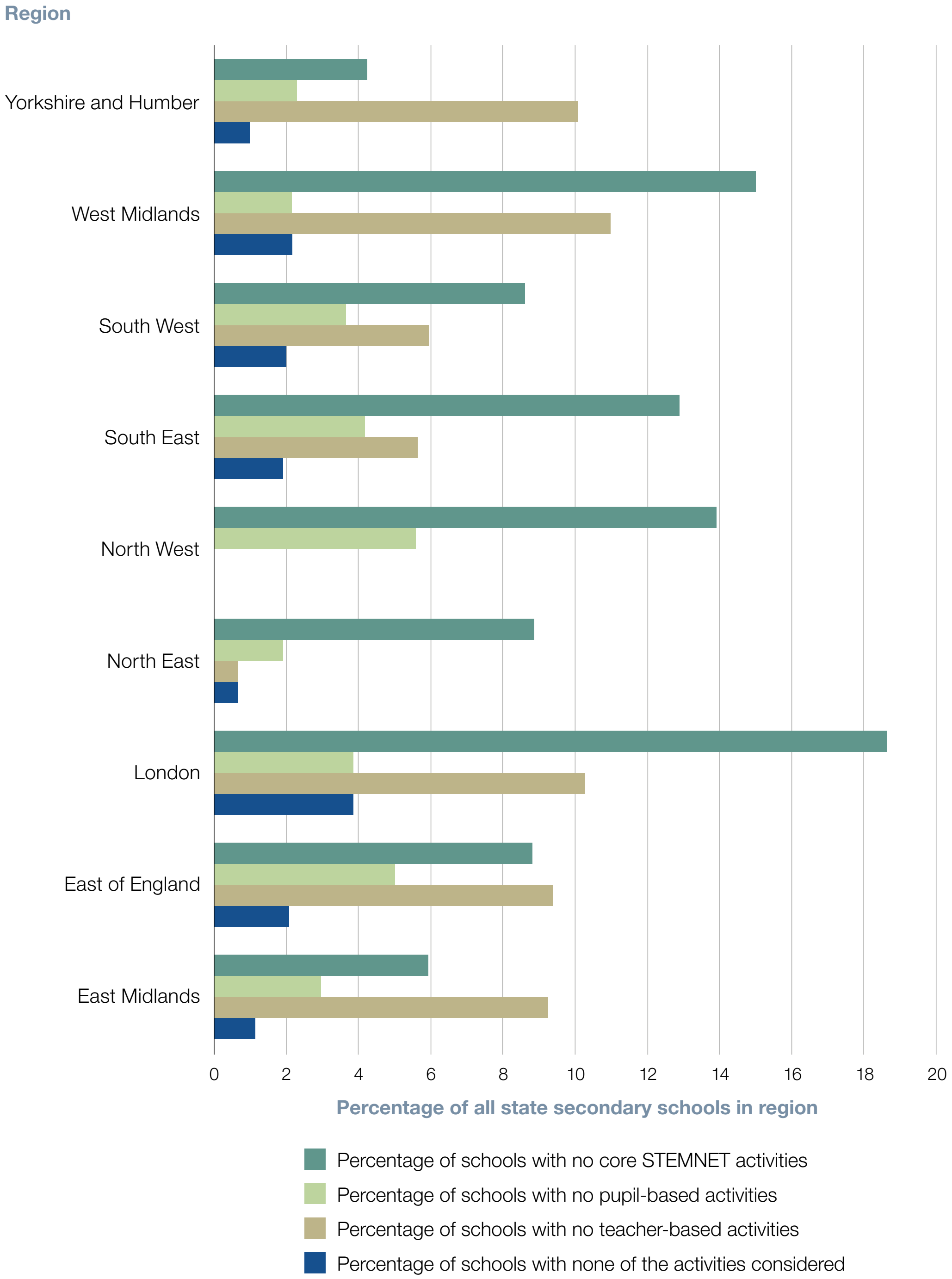
NOTE

1 Percentages are of state secondary schools (including maintained secondary schools, academies and city technology colleges) with GCSE results in 2008-09.

Source: National Audit Office analysis of National Pupil Database and intervention activity data

Figure 32

Percentage of state secondary schools not receiving different intervention types, by region



NOTES

1 North West Regional Science Learning Centre data was not available on a comparable basis with other Centres, and hence the North West region is excluded from the analysis for 'no teacher-based activities' and 'none of the activities considered'.

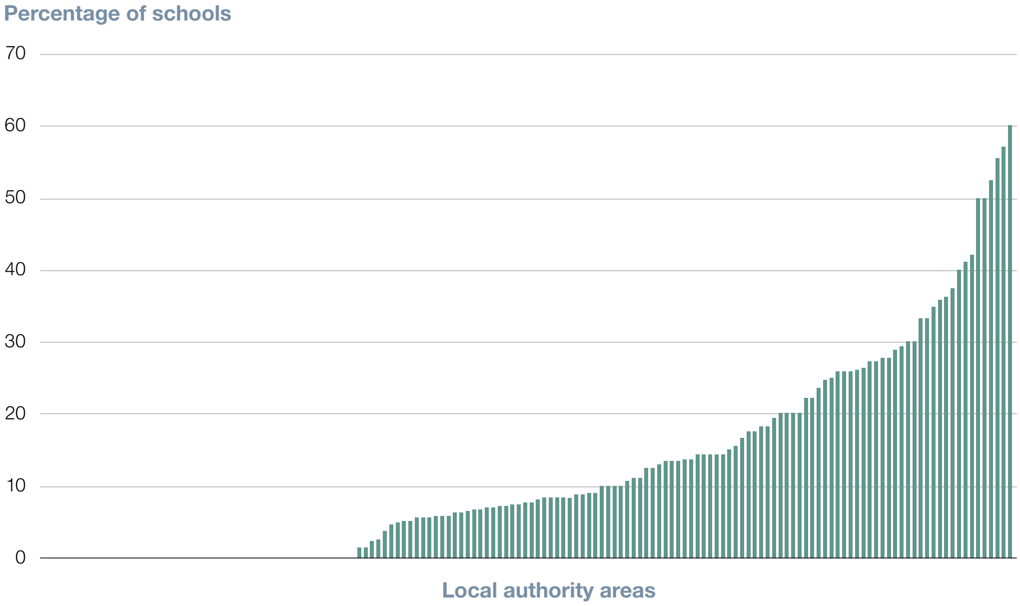
2 Includes maintained secondary schools, academies and city technology colleges.

Source: National Audit Office analysis of intervention activity data

3.44 At local authority level, too, there are significant variations in take-up of activities. For example, while in 48 of the 152 local authorities all secondary schools have participated in one or more STEMNET activities, in a further 29 areas at least a quarter of schools have not (**Figure 33**). Similarly, in just over a third of local authority areas for which comparable data is available, ten per cent of schools or more are not using any teacher-based interventions.

Figure 33

Percentage of state secondary schools with no core STEMNET activities in each local authority area



NOTE

1 In 48 local authority areas all secondary schools have participated in one or more STEMNET activities, hence these areas are not visible along the left-hand end of the x-axis.

Source: National Audit Office analysis of intervention activity data

Appendix

Methodology

Purpose	Method
To identify factors influencing pupils in continuing/not continuing with science, technology, engineering and maths	• Surveys of 1,274 pupils comprising those who remained in/left the 'STEM pipeline' after GCSEs, A-levels or first degrees in 2008 • Focus groups of three age groups in three regions • Literature review • International comparisons, including *Trends in International Mathematics and Science* and *the OECD Programme for International Student Assessment*
To analyse take-up and achievement in science and maths at GCSE and A-level	• Analysis of the National Pupil Database and ONS population estimates

To evaluate trends in take-up and achievement in science and maths associated with participation by schools in relevant Government-funded programmes	• Interviews and document review in the Department, the Department for Business Innovation and Skills and the Higher Education Funding Council for England
	• Analysis of take-up and achievement in GCSE biology, chemistry and physics, and A-level maths, biology, chemistry and physics at schools accessing/not accessing programmes. Linear regressions were performed on school-level participation data from programme providers, with output variables of
	  ◦ 2008-09 exam entries and grades A*-C (GCSE) and A-C (A-level);
	  ◦ Percentage change in exam entries and grades A*-C (GCSE) and A-C (A-level) between 2004-05 and 2008-09.
	• Literature review

Endnotes

1 Throughout this report, ‘the Department’ refers to the Department for Education or its predecessors, the Department for Children, Schools and Families and the Department for Education and Skills.

2 National Audit Office, *Mathematics performance in primary schools: Getting the best results* (HC 1151 Session 2007-2008, 19 November 2008), p. 8.

3 *SET for success: The supply of people with science, technology, engineering and mathematics skills – The report of Sir Gareth Roberts’ Review* (April 2002).

4 HM Treasury, DTI and Department for Education and Skills, *Science & innovation investment framework 2004-2014* (July 2004).

5 See, for example, Chemical Industry Education Centre, University of York, *Learning to love science: Harnessing children’s scientific imagination* (2008), p. 5.

6 Although GCSE grades D-G constitute a pass at ‘Level 1’ of the National Qualifications Framework, the usual definition of a ‘good pass’ (for example to progress to A-level) is A*-C. At A-level, grades A-E constitute a pass, with a ‘good pass’ often defined as A-C. To explore examination outcomes most likely to support successful progression, we focus on pupils achieving A*-C at GCSE and A-C at A-level.

7 Broeke, S. *Does offering more science at school increase the supply of scientists? The impact of offering Triple Science at GCSE on subsequent educational choices and outcomes* (Royal Holloway, University of London: Discussion Papers in Economics 10/01, 2010).

8 Ofsted, *Success in science,* p. 38.

9 Department for Children, Schools and Families, *Your child, your schools, our future: Building a 21st century schools system* (June 2009), p. 29.

10 HM Treasury, DTI, Department for Education and Skills and Department of Health, *Science and innovation investment framework 2004-2014: Next steps* (2006), p. 11.

11 See also Hutchinson, Stagg and Bentley, *STEM careers awareness timelines: Attitudes and ambitions towards science, technology, engineering and mathematics (STEM) at Key Stage 3* (University of Derby, 2009), p. 4.

12 Department for Children, Schools and Families, *Quality, choice and aspiration – A strategy for young people’s information, advice and guidance* (October 2009).

13 http://www.futuremorph.org/

14 See, for example, *Evaluation of Building Schools for the Future – 1st Annual Report* (December 2007), p. iii.

15 *Science and innovation investment framework 2004-2014,* p. 87.

16 *Science and innovation investment framework 2004-2014: Next steps,* p. 46.

17 CLEAPSS School Science Service, *Laboratories, Resources and Budgets – A report for the Royal Society of Chemistry on provision for science in secondary schools* (2004), p. v.

18 *Ofsted, The annual report of Her Majesty's Chief Inspector of Schools* 2004-05.

19 *Evaluation of Building Schools for the Future - 1st Annual Report,* p. 18.

20 CLEAPSS School Science Service, *Improving school laboratories? A report for the Royal Society of Chemistry on the number and quality of new and refurbished laboratories in schools* (2006), p. 3.

21 Quoted *Science and innovation investment framework 2004-2014: Next steps*, p. 43f.

22 Ibid.

23 See, for example, Chemical Industry Education Centre, University of York, *Learning to love science: Harnessing children's scientific imagination* (2008).

24 Source: NAO survey of 1,276 students who continued or abandoned science, technology, engineering and maths subjects after GCSEs, A-levels or first degrees in 2008.

25 OCR *Students and Science Report (2005),* p. 1.

26 *Public attitudes to science 2008 – A survey* (Research report for Research Councils UK and Department for Innovation, Universities and Skills, 2008), p. 48, 5.24.

27 Broeke, op. cit.

28 Calculated using proportion of pupils registered as eligible for Free School Meals.

29 Department for Education and Skills, *Report on the Science, Technology, Engineering & Maths (STEM) Mapping Review* (May 2004).

30 Department for Education and Skills / DTI, *The Science, Technology, Engineering and Mathematics (STEM) Programme Report,* p. 3.

31 http://www.stemnet.org.uk/home.cfm. In addition to brokering enhancement and enrichment activities, STEMNET also runs the STEM Clubs and STEM Ambassadors programmes.

32 *Science and innovation investment framework 2004-2014: Next steps* (2006), p. 43.

33 Ofsted, *Success in science (June 2008)*, p. 37.

34 Wellcome Trust, *Believers, seekers and sceptics* (January 2006), p. 4.

35 While similar activities are also provided to schools through other channels (for example universities working with local schools), routine data is not available to include these activities in our analysis. These potential omissions should not, however, result in any systematic bias in the results or the conclusions drawn.

36 E.g. R-squared model fit for the GCSE multiple regression is 0.06.

37 Department for Children, Schools and Families and Wellcome Trust, *Evaluation of the national network of Science Learning Centres – Final report* (January 2008).

38 *National network of Science Learning Centres: Report on impact 2008-2009,* p.16.

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